CARE AND OPERATION
OF
CENTRAL OFFICE POWER PLANT

ENGINEERING BULLETIN 140

NEW YORK TELEPHONE COMPANY

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9. VENTILATING PLANTS

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MOTORS, GENERATORS AND ASSOCIATED APPARATUS

DEFINITIONS

Armature

Generally the revolving part of a generator or motor.

Brushes

Used on generators or motors; are made of metal, carbon, graphite or a combination of these substances and are so placed that they bear upon the commutator, collector rings or interrupter rings, and conduct the current to or from the external circuit.

Brush Holders

Devices for supporting the brushes of a generator, motor, or interrupter ring.

Brush Holder Stud

The detail of the rocker arm on which the brush holders are mounted.

Brush Rocker or Rocker Arm

The arm or ring on which the brush holders are mounted for the purpose of shifting the brushes on the commutator or collector ring of a generator or motor.

Brushes, Staggered

Brushes so placed that those on one stud will overlap the part of the commutator covered by those on the adjacent stud to insure even commutator wear. (See page 26)

Choke Coil

A coil of very low ohmic resistance and high impedance placed in the charging circuit and between storage battery and battery driven machines for the purpose of smoothing out fluctuations in current caused by commutation.

Circuit Breaker

A device for opening a circuit automatically when the current increases above, or decreases below, the specified limits. (See pages 27, 28 and 29)

Collector Rings

Solid brass or copper rings attached to and revolving with the armature of a ringing generator, and connected to the alternating current winding, and which serve to conduct the current through the brushes to the external circuit.

Collector Rings, Split

A collector ring divided into two approximately equal segments, connected to and revolving with the armature of a ringing generator, which serve to conduct the positive and negative impulses through the brushes to the external circuit.

Commutator

Insulated copper segments, assembled in cylindrical form, at the end of and connected to the armature windings, and which serve to conduct the current through the brushes to or from the external circuit.

Commutator Bar or Segment

One of the insulated copper sections of the commutator.

Commutator Tang

The end of the commutator bar to which the armature winding is connected.

Direct Connected Set—See Motor Generator Set

Dynamotor

A machine having a motor and generator winding on the same armature, with a common field. This term is also applied to certain ringing generators having a separate armature winding to excite the field.

Field Windings

The copper wire coils which are wound on the stationary pole pieces of motors and generators.

Generator

Any mechanically driven machine for producing electric current.

Generator, Charging

A direct current generator used to charge storage batteries.

Generator, Coin Collector

A direct current generator used to furnish current for operating coin collector apparatus. (See page 30)

Generator, Message Register

A direct current generator used to furnish current for operating message registers. (See page 31)

Generator, Ringing

A generator used to furnish alternating and pulsating ringing currents. (See pages 32 and 33)

Generator, Shunt Wound

A generator having the field winding connected in parallel with the armature winding and the external circuit. (See pages 27, 28 and 29)

Generator, Compound Wound

A generator having two distinct field windings, one of which is connected in parallel and the other in series with the armature winding and the external circuit. (See pages 30 and 31)

Interrupters

A commutating apparatus connected to a ringing generator for the purpose of interrupting a direct, pulsating, superimposed or alternating current, in order to produce a tone or operate a signal.

For #84 Type, See Section on Pole Changers.

Motor

A rotating machine which transforms electrical energy into mechanical power.

Motor, Alternating Current

A motor operated by alternating current. Those generally used are of the induction type and may be single phase, two phase, or three phase.

Motor, Direct Current

A motor operated by direct current.

Motor, Differentially Wound

A direct current motor having two distinct field windings, one of which is connected in parallel and the other in series with the armature winding and the external circuit. These windings are so connected that they are magnetically opposed, for the purpose of speed regulation. (See page 34)

Motor, Shunt Wound

A direct current motor having the field winding connected in parallel with the armature winding and the external circuit. (See page 35)

Motor-Generator Set

A combination of a motor and a generator mounted on a common base, with the shafts coupled together.

Oil Gauge

A glass tube for indicating the height of the oil in the reservoir.

Oil Rings

Metal rings placed loosely upon the shafts of motors and generators and which, in revolving, carry oil from the reservoir to the bearings.

Pole Pieces

Generally, stationary parts of a generator or motor between which the armature revolves, and which are magnetized by the current passing through the field windings.

Reserve Set

A charging, ringing, message register or coin collector unit which is intended to be used in case of failure of the regular set.

Residual Magnetism

The magnetism retained by the poles of a generator after the exciting current flowing in the field windings has been interrupted.

Rheostat

A variable resistance, adjusted by a hand wheel or lever, connected in series with the apparatus through which it is desired to regulate the current flow. (See page 36)

Rheostat, Charging

A rheostat placed in series with a source of direct current supply to control the flow of current through a battery.

Rheostat, Compound

A main and auxiliary field rheostat connected in series. The approximate adjustment is obtained with the main rheostat and then the exact adjustment by using the auxiliary rheostat. (See page 37)

Rheostat, Field

A rheostat connected in series with the field windings of a generator or motor for varying the current flow through the field windings thereby regulating the voltage or speed.

Rheostat, Starting—See Starting Box

Split Rings—See Collector Rings

Starting Box, Direct Current

A rheostat equipped with an overload and no voltage releasing device, wired in series with the armature circuit of a direct current motor for starting it gradually. (See page 35)

Starting Box Combined with Field Rheostat

A device used in connection with battery driven ringing motor-generator sets which combines the function of a starting box and field rheostat as described above. The field rheostat feature is used to obtain a constant speed under varied battery voltages. (See page 38)

Starting Box, Single Phase Motors

A device so arranged that with resistance and impedance the phase can be split for starting purposes. (See pages 40 and 41)

Starting Compensator or Auto Starter

A device, used in starting induction motors by voltage control, consisting of a transformer combined with a suitable switching arrangement. (See page 39)

OPERATION

The following types of electric machines are used in telephone work:

DIRECT CURRENT MOTORS.

ALTERNATING CURRENT MOTORS.

DIRECT CURRENT GENERATORS, used for charging storage batteries, operating message registers and coin collector apparatus.

ALTERNATING and PULSATING CURRENT RINGING GENERATORS.

DIRECT CURRENT MOTORS

A. Line and Battery Driven Motors.

To Start

1. See that starting box arm is in open circuit position.
2. Remove insulating fibre stops from switch jaws.
3. Move starting box arm to first contact, as indicated by mark on face of board.
4. Close motor switch. If motor fails to start, open switch and investigate.
5. Turn starting box arm slowly until it engages holding magnet. If the holding magnet fails, open switch. Never open the motor circuit by permitting the lever arm to return to open circuit position with switch closed.

To Stop

1. Open motor switch.
2. See that starting box arm returns to open circuit position.
3. Replace insulating fibre stops in switch jaws.

B. Battery Driven Ringing Motor with Combined Starting Box and Field Rheostat.

To Start

1. See that starting box arm is in open circuit position.
2. Remove insulating fibre stops from switch jaws.
3. Move starting box arm to first contact, as indicated by mark on face of board.
4. Close motor switch. If motor fails to start, open switch and investigate.
5. Turn starting box arm slowly until it engages holding magnet. If the holding magnet fails, open switch. Never open the motor circuit by permitting the lever arm to return to open circuit position with switch closed.
6. Continue to turn hand wheel until the proper alternating current voltage is reached, or to the point indicated corresponding to the battery voltage.

To Stop

1. Open motor switch.
2. See that starting box arm returns to open circuit position.
3. Replace insulating fibre stops in switch jaws.

ALTERNATING CURRENT MOTORS

A. Small Alternating Current Motors with No Starting Device or with Automatic Starting Device in Motor.

To Start

1. Remove insulating fibre stops from switch jaws.
2. Close motor switch.

To Stop

1. Open motor switch.
2. Replace insulating fibre stops in switch jaws.

B. Motors with Starting Compensator or Auto Starter.

(A) DRY TYPE WITH DOUBLE THROW SWITCH.

To Start

1. Remove insulating fibre stops from switch jaws.
2. Close switch on side marked "Start".
3. When the armature has reached normal speed (which can be determined by the sound) throw switch quickly from the "Start" position to the other side marked "Run". The switch must not be closed on the "Running" side before the armature has reached normal speed, nor allowed to remain in "Starting" position after normal speed has been reached.

To Stop

1. Open motor switch.
2. Replace insulating fibre stops in switch jaws.

(B) OIL IMMERSED TYPE WITH HAND WHEEL OR LEVER.

To Start

1. Turn hand wheel or lever to "Start" position.
2. When armature reaches full speed, **not before,** turn hand wheel or throw lever quickly to "Run" position.

To Stop

Turn hand wheel or lever quickly but carefully to "Off" position.

NOTE: When auto starter is equipped with no voltage release, press push button to stop; and note that lever returns to "Off" position.

C. Alternating Current Motor with Switch and Starting Box.

To Start

1. Remove insulating fibre stops from switch jaws.
2. Close motor switch.
3. Turn starting box arm slowly until held by the clutch.

To Stop.

1. Open motor switch.
2. Release starting box arm.
3. Replace insulating fibre stops in switch jaws.

D. Alternating Current Motor with Split Phase Starting Box.

(A) EQUIPPED WITH SWITCH.

To Start

1. Remove insulating fibre stops from switch jaws.
2. Close motor switch.
3. Turn starting box arm slowly to "Start" position.
4. When armature reaches full speed, **not before,** turn arm back slightly toward "Off" position so as to release clutch, and then quickly to "Run" position.

To Stop

1. Open motor switch and note that lever arm of starting box returns to "Off" position.
2. Replace insulating fibre stops in switch jaws.

(B) WITHOUT SWITCH.

To Start

1. Turn starting box arm slowly to "Start" position.
2. When armature reaches full speed, **not before,** turn arm back slightly toward "Off" position so as to release clutch, and then quickly to "Run" position.

To Stop

1. Operate manual release and note that lever arm of starting box returns to "Off" position.

DIRECT CURRENT GENERATORS

Charging Generators

To Start

1. Start motor or gas engine which drives generator, as described under "Motors" or "Gas Engines".
2. See that generator brushes are making contact with commutator.
3. Close circuit breaker.
4. Read battery voltage.
5. Remove insulating fibre stops from switch jaws.
6. Manipulate generator field rheostat to obtain a generator voltage about one volt higher than voltage of battery.
7. Close generator switch and charging transfer switch, where provided, and regulate current by manipulating field rheostat.

   In case of small batteries equipped with charging rheostats, current should be regulated by adjusting both rheostats.

To Stop

1. Adjust generator field rheostat until current is reduced to nearly zero.
2. Open circuit breaker.
3. Open generator switch.
4. Turn rheostat arm until all resistance is cut in.
5. In the case of the gas engine charging sets raise brushes from commutator, if style of holder permits.
6. Stop motor or gas engine, as described under "Motors" or "Gas Engines".
7. Replace insulating fibre stops in switch jaws.

GENERATOR CAPACITY

In offices where the maximum required generator output cannot be supplied by one generator without exceeding its

rated capacity in amperes, the power plant supervisor shall determine under what conditions and to what extent, if any, the rated capacity shall be exceeded, and under what conditions two generators shall be operated in parallel.

PARALLEL OPERATION

To Start

1. Start one charging generator, as described above, and regulate current to about 20 amperes.
2. Start second charging generator and regulate in same manner as first, giving particular attention to reading of battery voltage, which will be higher than when starting first generator.
3. Regulate current of generators so that each furnishes its proper share of total generator output. If charging units are equal in capacity and are connected to same source of power each generator should carry 50 per cent. of total output. If charging units differ in capacity or are connected to different sources of power, a different proportion may be more efficient.

To Stop

1. Adjust current of each generator to about 20 amperes.
2. Stop first one generator and then the other as described above.

Message Register and Coin Collector Generators

To Transfer Load from one Generator to Another

1. Start motor which drives generator to be cut into service as described under "Motors".
2. Manipulate regulating rheostat to obtain same voltage as obtained on generator in operation.
3. Remove insulating fibre stops from generator switch jaws.

4. Close generator switch, throwing both generators in parallel, except where machine has failed or trouble developed.

   NOTE: In case a machine fails, open its generator switch before closing generator switch of machine to be cut in service.

5. Open generator switch of generator which is to be cut out of service.
6. Replace insulating fibre stops in switch jaws.
7. Stop motor connected to generator which has been cut out of service, as described under "Motors".

ALTERNATING CURRENT GENERATORS

Ringing Generators

To Transfer Load from one Generator to Another

1. Start motor which drives generator to be cut into service, as described under "Motors".
2. If ringing set is provided with a regulating device adjust ringing voltages to their normal value.
3. Throw over secondary switches.
4. Stop motor connected to generator to be cut out of service, as described under "Motors".

When exchange load is transferred from one ringing machine to another, "A" and "B" board ringing current, tone test, out of order, busy back, etc., shall be tested to insure accuracy of operation. A head receiver shall be used for making this test.

RESERVE SETS

Reserve sets shall be operated so as to carry the Central Office load at least two hours each week. Careful attention should be given to commutators, brushes and bearings. It may be necessary in some central offices to operate charging sets while test on ringing and message register sets is being made, so as to avoid excessive battery discharge.

POWER APPARATUS IN THE HANDS OF WESTERN ELECTRIC COMPANY

A. Power Apparatus in the Hands of Western Electric Company for Repairs will be tagged as follows:

1. "Out of Service".
2. "Do not use except in case of emergency".
3. "Should be used. Under observation by Western Electric Company."

Western Electric Company's representative will, in all cases, call wire chief's attention to the tag.

Apparatus with a #3 tag attached shall be used according to regular routine, and defects which develop shall be noted and reported to the office.

B. Power Plant Installation or Extensions by the Western Electric Company, from the time put into service until accepted by Telephone Company, will be tagged as follows:

"Notice to Wire Chief: Power apparatus listed below is in the hands of the Western Electric Company. It is available for use and the Telephone Company is expected to care for ordinary routine maintenance.

"Report to Engineering Department, via usual channels, any conditions involving special maintenance or repairs."

The apparatus listed on the tag shall receive ordinary maintenance of a routine character.

If trouble is experienced or conditions arise which seem to be due to inherent defects in the apparatus, or faulty installation, or where conditions arise which would involve maintenance of a special character, the case shall be referred to the office before work is done to remedy the conditions, unless the telephone service is jeopardized, in which case the trouble shall be cleared and a report made as soon as possible.

TROUBLES

Failure of Outside Power

In case of failure of outside power the reserve machines shall be started in the following order:

1. Ringing Set.
2. Message Register Set.
3. Coin Collector Set.
4. Charging Set.

MOTORS

Failure to Start may be due to:

1. Failure of outside power.
2. Loss of one or more phases of a two or three phase circuit.
3. Open fuse.
4. Brushes not making contact with commutator.
5. Open armature circuit.
6. Open field circuit.
7. Open starting box.

GENERATORS

Failure to Build up Voltage when Starting may be due to:

1. Poor contacts of brushes with commutator.
2. Open armature or field circuit.
3. Loss of residual field magnetism (if self exciting).

Reversed Voltage may be due to:

1. Reversed connections.
2. Reversed residual field magnetism (if self exciting).

Loss or Reversal of Residual Field Magnetism of a Charging Generator may be remedied as follows:

1. Raise or insulate all brushes from commutator.
2. Close circuit breaker.
3. Close generator switch for a few seconds to allow battery current to flow through field coils.
4. Open circuit breaker and generator switch, restore brushes and start generator as described under "Charging Generators".

Loss or Reversal of Residual Field Magnetism of a Message Register or Coin Collector Generator may be remedied as follows:

1. Remove or insulate all brushes from commutator.
2. Close generator switch for a few seconds to allow current from the generator which is running to flow through the field coils.
3. Open generator switch, restore brushes and start generator as described above.

In case of Failure of All Machines, if Reversed, the polarity may be corrected temporarily by reversing the generator armature leads at the connecting block or machine.

Interruption of Message Register Current for a short period before another machine is thrown on the circuit, may necessitate requesting the Traffic Department to release all register keys to prevent the starting box from tripping on an overload.

Variation in Load, indicated by fluctuating ammeter or voltmeter needle, may be due to poor brush contact of motor or generator, or to poor connection or partial open in armature or field circuit.

An Open Armature Coil can generally be located by a careful inspection of the commutator bars, as the excessive sparking will pit the bars in which the broken coil terminates.

A Short-circuited Field Coil may be detected by its remaining cool while the others heat up excessively.

Streaks of Fire on Commutator indicate presence of conductive material between segments.

Heavy Load on Ringing Machine due to cable failure may be relieved by unscrewing resistance lamps of circuits in trouble.

In case of Total Failure of all Ringing Machines emergency ringing circuits shall be established with another office.

Overheating of Bearings may be due to:

1. Excessive belt tension.
2. Failure of oil rings to revolve.
3. Rough bearing surface.
4. Bent shaft.
5. Insufficient amount or poor grade of oil.
6. End thrust due to improper levelling.
7. Improper alignment.
8. Large unbalanced magnetic pull due to the armature not being central with the frame; generally resulting from excessive wear of the bearings.
9. Oil grooves in journal box stopped up.
10. Dirty oil or grit.

Overheating of Commutator may be due to:

1. Overload.
2. Excessive brush tension.
3. Excessive brush sparking.
4. Brushes not being in proper position.

NOTE: If commutator becomes excessively heated, the load should be thrown off and machine stopped at once.

Sparking may be due to:

1. Oily or dirty commutator.
2. Brushes not properly adjusted.
3. Brushes burned on the ends.
4. Rough commutator.
5. A high, low, or loose commutator bar.
6. High mica between segments.
7. Open circuit in armature winding or conductors.
8. Loose connections of armature conductors.
9. Crossed armature windings or commutator segments.
10. Copper picked up by the brushes.

Excessive Field Heating may be due to:

1. Rocker arm out of proper position.
2. Overload (this may be due to inaccurate ammeter).
3. Low primary or motor voltage, which would be indicated by decrease in speed.
4. Abnormal generator voltage caused by circuit breaker opening, or all resistance of rheostat in battery #2 charging circuit being cut in.

Throwing or Leaking of Oil may be due to:

1. Oil too high in bearings.
2. Shaft not level.
3. End plate on the bearing not properly sealed.

Machine Noise on the Battery may be due to:

1. Poor brush contact.
2. Sparking at brushes.
3. Dirty commutators on charging generators or battery driven sets.
4. Slipping of belt.
5. Loose connections.
6. Improper location of brushes.

CARE AND MAINTENANCE

Cleaning Machines

Machines and power apparatus shall be kept clean and in good repair at all times. With the exception of commutators, machines shall not be cleaned while in motion, but shall be cleaned immediately after shutting down, while in a heated condition.

Charging Sets

At the end of each run the set shall be cleaned as follows:

1. Dust all parts.
2. Clean commutators.
3. Clean seats of brushes.
4. Wipe off shaft to prevent oil creeping on commutator or armature.

On alternate weeks each set shall receive a thorough cleaning which, in addition to the above, shall be as follows:

1. Blow out, with an air blast or bellows, the space between the tangs of commutators not enclosed, to remove dirt and copper dust.
2. Reseat carbon brushes, where used, if necessary.

(See Carbon Brushes page 22)

In Offices where Three Charging Sets are installed, two sets shall be thoroughly cleaned in one week and the other set on alternate weeks.

Message Register Sets

One set shall be cleaned daily as follows:

1. Dust all parts.
2. Wipe off shafts and commutators.
3. Clean and, if necessary, reseat brushes.

Ringing Generator Sets

One set shall be cleaned daily as follows:

1. Dust all parts.
2. Wipe off shafts and commutators.
3. Clean and, if necessary, reseat brushes.
4. Polish collector rings and interrupters.

Coin Collector Sets

One set shall be cleaned daily as follows:

1. Dust all parts.
2. Wipe off shafts and commutators.
3. Clean and, if necessary, reseat brushes.

Reserve Sets

The reserve message register, ringing generator and coin collector sets shall be cleaned as explained under the respective headings above and as follows:

1. Where covers are provided, once a week.
2. Where covers are not provided, on alternate days.

Commutators

While in motion, commutators shall be cleaned hourly or oftener with cheese-cloth, not waste, slightly moistened with kerosene to which an equal quantity of dynamo oil has been added. The cloth should be held against the commutator with some force. Where carbon or graphite brushes are used the commutator should then be wiped dry with a clean cloth.

Special care should be taken to prevent oil from getting on the commutator except as above. Commutator compounds, commutator pastes, vaseline or paraffine shall not be used. A commutator shall not be smoothed with a file or emery cloth. In general, sand-paper shall not be used except under direction of power plant supervisor.

With proper care, a commutator should have a smooth highly burnished surface of a color somewhat similar to blued steel.

A commutator should run without vibration and should not heat excessively.

NOTE: The specified temperature limit of a commutator is 158° F.

Turning down, sanding and repairing commutators shall be handled by the power plant force unless otherwise directed.

Interrupter and Collector Rings

Interrupter and collector rings of ringing generators shall be kept polished by use of an approved burnishing paste.

Care should be exercised to prevent oil getting on interrupter and collector rings.

Fibre and brass gear wheels shall be lubricated by means of vaseline but in the case of the fibre wheels only a small quantity shall be used, as an excessive amount is liable to soften the fibre.

The enclosed gears of the SC type interrupter shall be lubricated by means of dynamo oil.

Brushes and Brush Holders

Brushes shall be properly seated to insure good contact with commutators.

The spring tension shall be uniform, and sufficient to insure easy riding contact.

Excessive spring tension shall be avoided as it has a tendency to overheat the commutator.

Brushes shall not be removed nor any work done on the brush holders that would cause the brushes to become displaced, while the machine is in motion.

Metal Brushes

When cleaning, metal brushes shall not be removed from the holder; they shall be snapped upon the commutator to loosen the dust, which shall then be blown away.

Seats of metal brushes shall be cleaned by wiping with cheese-cloth moistened with kerosene and, if necessary, by scraping lightly in the direction of rotation to remove the coating of oil and dust. Sandpaper shall not be used.

Seating, staggering and cutting of metal brushes will be done by the power plant force unless otherwise directed. The following method shall be used:

The brushes should first be spaced and set. Then cut a piece of sandpaper (#1½) the width of the commutator and of a length sufficient to go around the commutator and meet with a butt joint. The sandpaper should be drawn tightly around the commutator, sand side out, and held in place by means of Le Page glue applied to the commutator at the joint. The paper should be held in place by twine wrapped around the commutator until the glue has hardened. The brushes should then be lowered on to the sandpaper. The pressure of the brushes should be about the same as when in regular service. The armature should then be revolved at normal speed until the brushes have been sanded on their entire contact surface. The brushes should then be raised and the sandpaper and glue removed from the surface of the commutator and the latter thoroughly cleaned. A cloth moistened with water should be used to remove the glue. The machine should be carefully cleaned, all copper dust being removed by blowing and wiping. The contact surface of the brushes should be wiped off with a cloth moistened with kerosene so as to remove any particles of grit which may adhere to the brushes.

The armature of a machine equipped with metallic brushes shall not be turned backwards while brushes are in contact with commutators, as this operation will injure the brushes.

Carbon Brushes

Carbon brushes in reaction holders may be removed but care shall be taken to replace each brush in its original holder.

Carbon brushes shall be reseated by drawing a strip of #00 sandpaper back and forth under brush with sand side next to brush, holding paper to surface of commutator so that

contact surface of brush will conform to curvature of commutator. The last few strokes of the sandpaper shall be in direction of rotation only. In no case shall brushes be scraped. (See page 42)

To avoid chipping, carbon brushes shall be slightly bevelled at the toe. Copper plating on carbon brushes shall at all times be cut back 1/16″ from commutator surface.

The different sets of brushes shall be set at equal distances around the commutator. All brushes of a set shall cover the same segments and each set shall cover the same number of segments. The proper number depends on the type of machine and for charging generators is indicated in the following table:

No. of Poles	Type and Size	Watts	Volts	Amps.	Range of Speed R.P.M.	Minimum No. of Segments to be Covered by Brush
4	M1	750	30	25	1700–1950	2½
4	M1	1,050	42	25	1700–1950	2½
4	M2	1,500	30	50	1700–1950	2½
4	M2	2,100	42	50	1700–1950	2½
4	M3	3,000	30	100	1100–1200	3
4	M3	3,000	30	100	1700–1800	3
6	M4	5,250	30	175	1100–1250	2
6	M5	6,750	30	225	1100–1250	2
4	M5½	9,000	30	300	1100–1200	6
4	M5½	12,000	30	400	1100–1200	6
4	M7	18,000	30	600	850–925	5
6	M8	24,000	30	800	850–975	4
6	M9	30,000	30	1000	475–500	6

The rocker arm shall be set so that the brushes make contact at the non-sparking points. These are designated by suitable markers on the rocker arm and on frame of machine.

The rocker arm controlling position of brushes on machine shall not be moved outside of markers above referred to without special permission from Wire Chief. All such cases shall be referred to the power plant supervisor.

Each alternate set of brushes shall be so adjusted or staggered with respect to the others that brush contact is evenly distributed over the whole commutator surface, thereby distributing or reducing wear of commutator. (See page 26)

Bearings

Only approved grades of lubricating oils shall be used, a sufficient stock of which shall be kept on hand at all times.

Special care shall be taken to prevent grit or any other foreign substance from entering bearings, oil cups or oil cans.

Oil cups and reservoirs shall be kept filled to proper level and air hole in gauge kept open.

Oil rings shall be inspected daily, immediately after machine is started, to see that they are revolving freely.

Special care shall be exercised to avoid leakage of oil due to overfilled reservoirs or other causes. Continued leaking shall be reported to Wire Chief.

Bearings shall be observed hourly or oftener to detect excessive heating.

In case a hot bearing develops the load on the machine shall be taken off and, if possible, the speed reduced. The bearing should then be flushed with dynamo oil until cool. The set should in no case be stopped unless there is danger of the armature striking the pole pieces.

Ringing machine interrupters, with hollow shaft oiling device, shall be lubricated with clean, pure, vaseline made as soft as can be handled by adding dynamo oil. Once a month the shaft shall be carefully cleaned out and filled with new lubricant, special precautions being taken to prevent anything entering which could stop up the small opening from the hollow shaft to the bearing.

Machine Covers

Whenever practicable, two men shall be used in replacing machine covers, on account of the liability of breaking field wires. Machines shall not be entirely covered until they are cooled off.

Painting

Paint shall not be applied to any part of the power plant without permission from the power plant supervisor.

Power Switchboard and Fuse Panels

Under no circumstances shall instrument seals be broken or ammeter shunt leads repaired by the central office force.

Slate panels shall be cleaned periodically with bone black mixed with an approved cleaning oil.

Inspection of Power Board Connections

Inspection of all connections on the power board shall be made annually by the power plant force.

Circuit Breakers, Starting Boxes, Rheostats, Etc.

The contacts of circuit breakers, starting boxes, rheostats, voltmeter switches and switch blades shall be cleaned weekly; this to insure good contact and to prevent heating. Cheesecloth slightly moistened with kerosene shall be used. In some cases it may be necessary to use crocus cloth, but in no case shall anything coarser be used. Special care shall be taken to protect lacquered surfaces.

Circuit Breakers in Charging Circuits

1. **Operation.** Circuit breakers in storage battery charging circuits shall be set to operate on reversed current and on an overload current not greater than the capacity of the generator nor greater than the rated capacity of the smallest fuse in the circuit. The overload current at which it should operate shall be marked on or near each circuit breaker.

2. **Test.** Circuit breakers shall be tested weekly as follows:
   (a) Overload. While charging, increase generator output to the value marked on or near circuit breaker. Circuit breaker should operate at this point.

(b) Reverse Current. While charging reduce generator output to zero. When needle indicates slightly below zero, if circuit breaker fails to operate automatically trip breaker at once by hand.

Starting Boxes

Test. Starting boxes shall be tested weekly as follows:

(a) No Voltage Release. While the motor is running, open motor switch and observe action. Starting box arm should release and return to open circuit position before motor stops.

(b) Overload Release. While the motor is running, lift armature of overload device and observe action. Armature should be pulled up and held by the coil and motor should stop. Starting box arm in some types will release and return to open circuit position; in other types an auxiliary arm operates and opens circuit. After making test, motor switch shall be opened.

(c) Note that armature of overload device is set at point indicated by white mark on plate.

(d) Inspect contacts and connections.

NOTE: In making tests of circuit breakers and starting boxes as described above a failure to operate properly shall be immediately reported to Wire Chief.

Rheostats

Rheostats shall be inspected weekly to see that movable and stationary contacts are in good condition, that they make good contact and do not heat excessively. Handles shall turn freely and arrows indicate correctly.

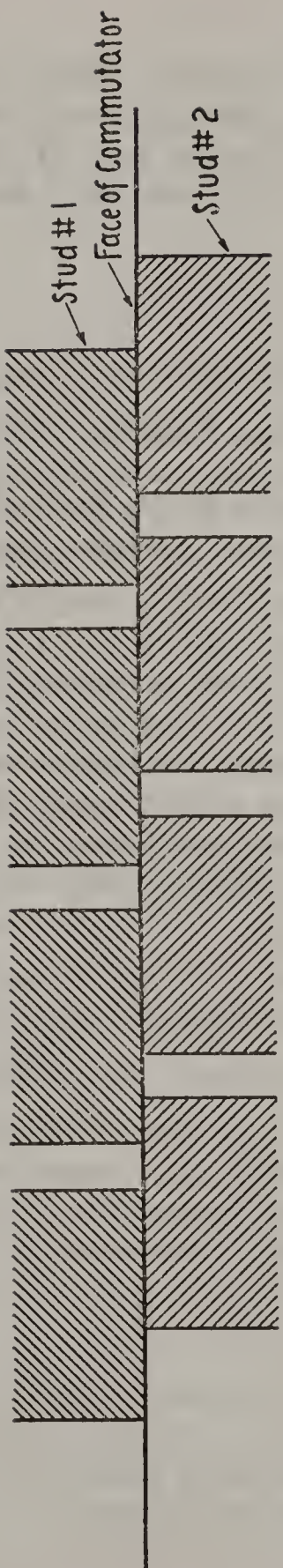

Fig. 1. Staggering of Brushes.
(See pages 1 and 23)

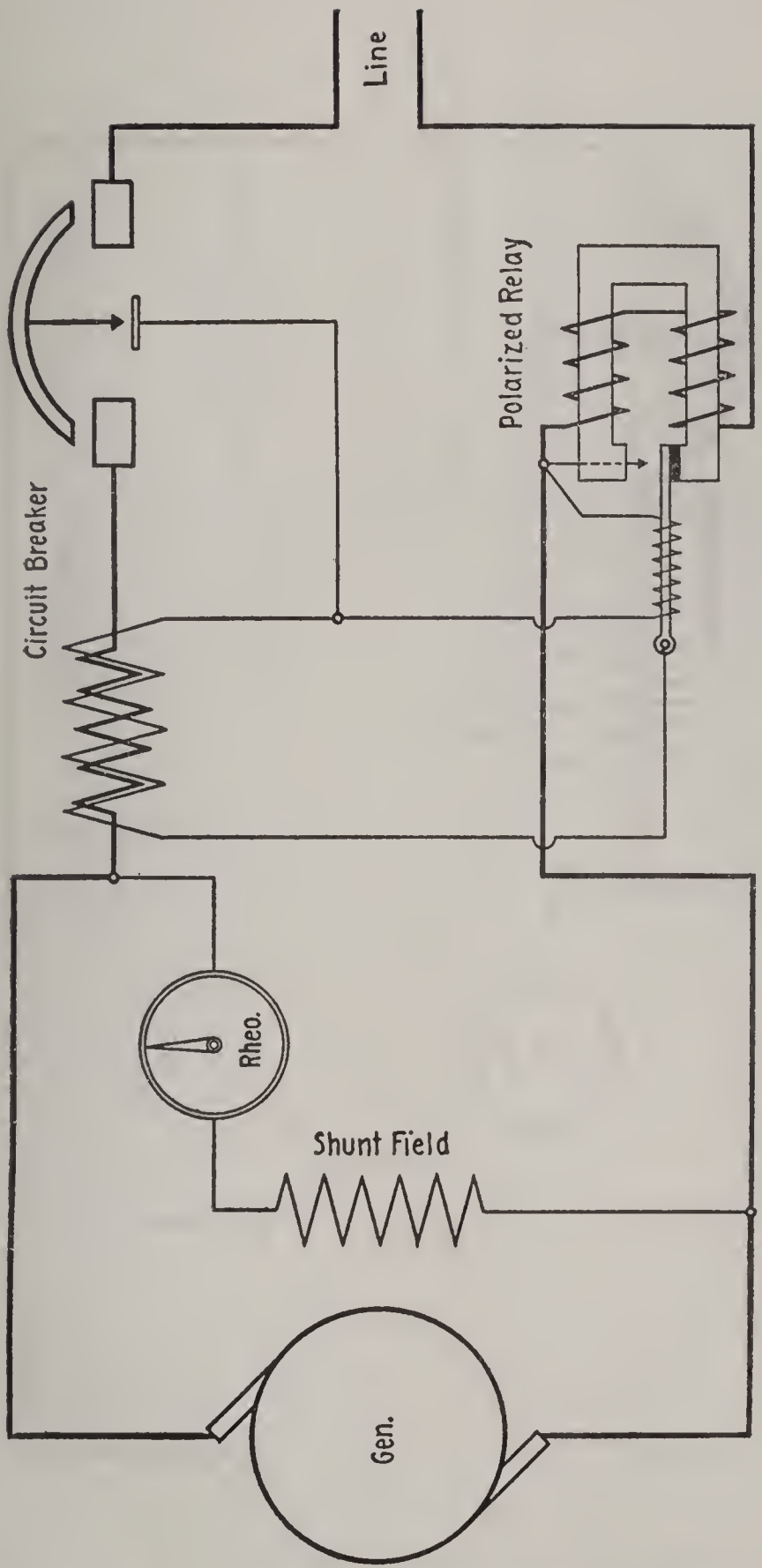

Fig. 2a. Circuit Breaker with Polarized Relay. (Overload and reversed current protection)

(See pages 2 and 3)

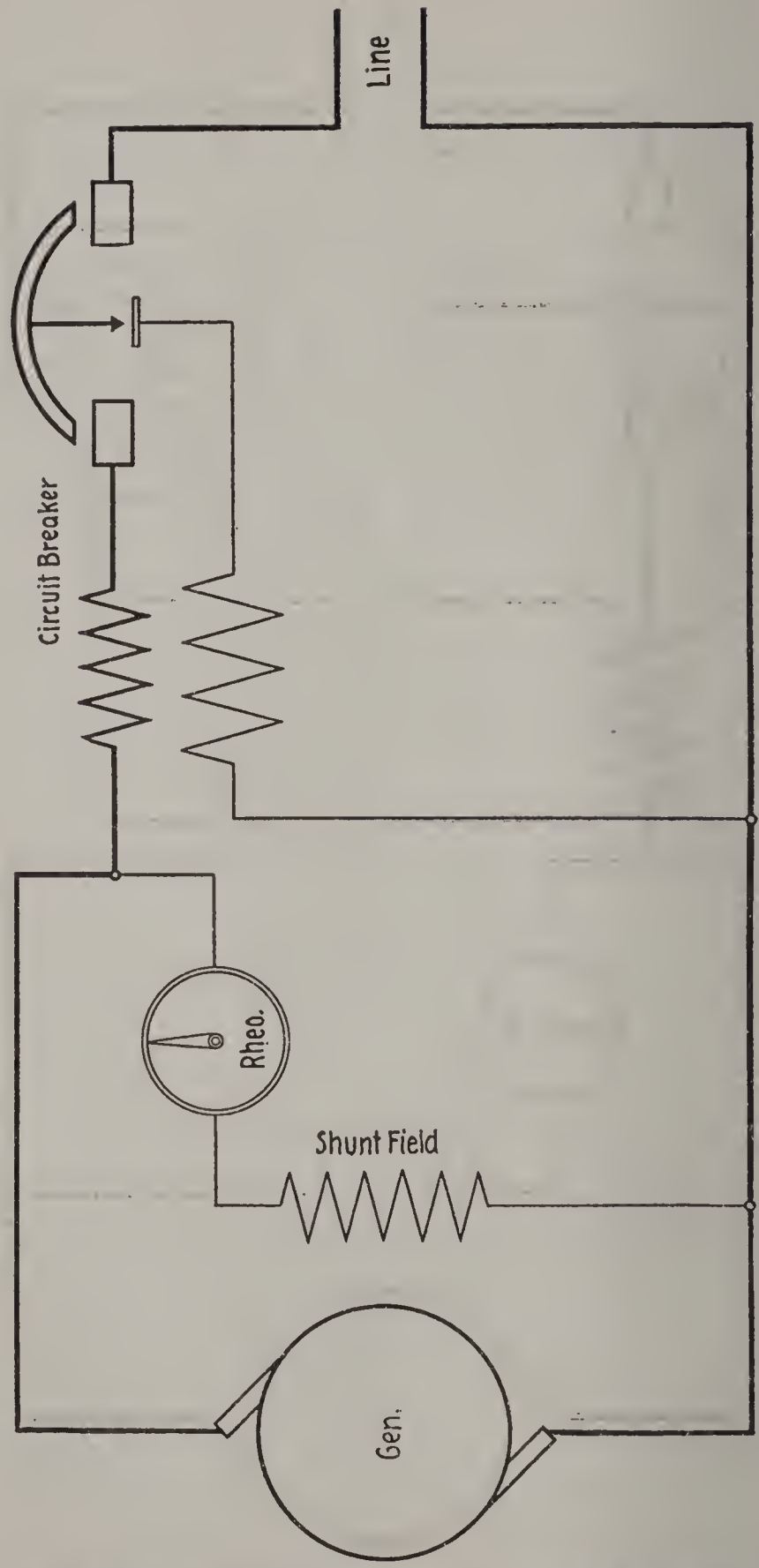

Fig. 2b. Circuit Breaker, Reversite Type. (Overload and reversed current protection)

(See pages 2 and 3)

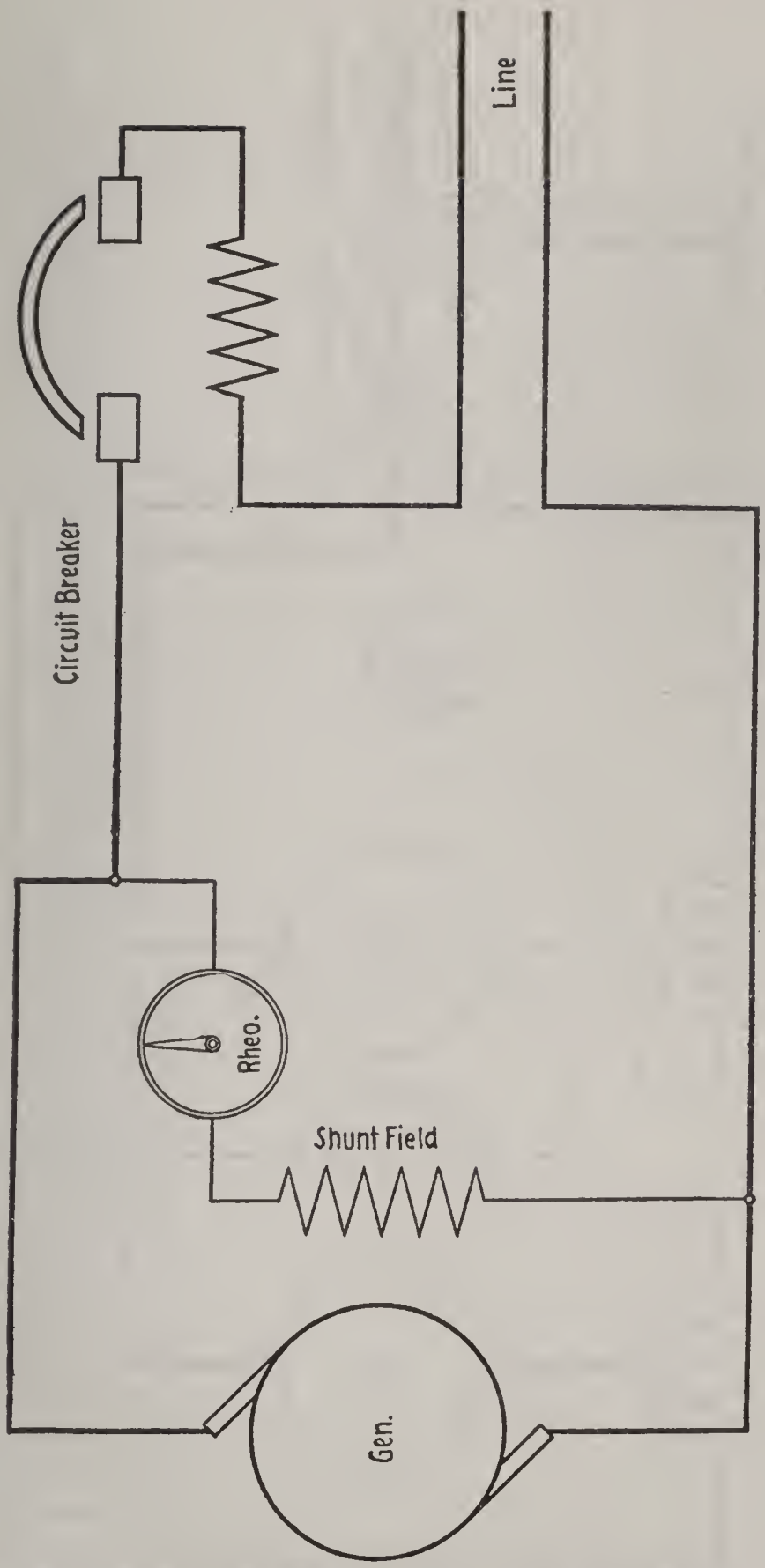

Fig. 2c. Circuit Breaker, Plain Underload Type. (No protection against overload)

(See pages 2 and 3)

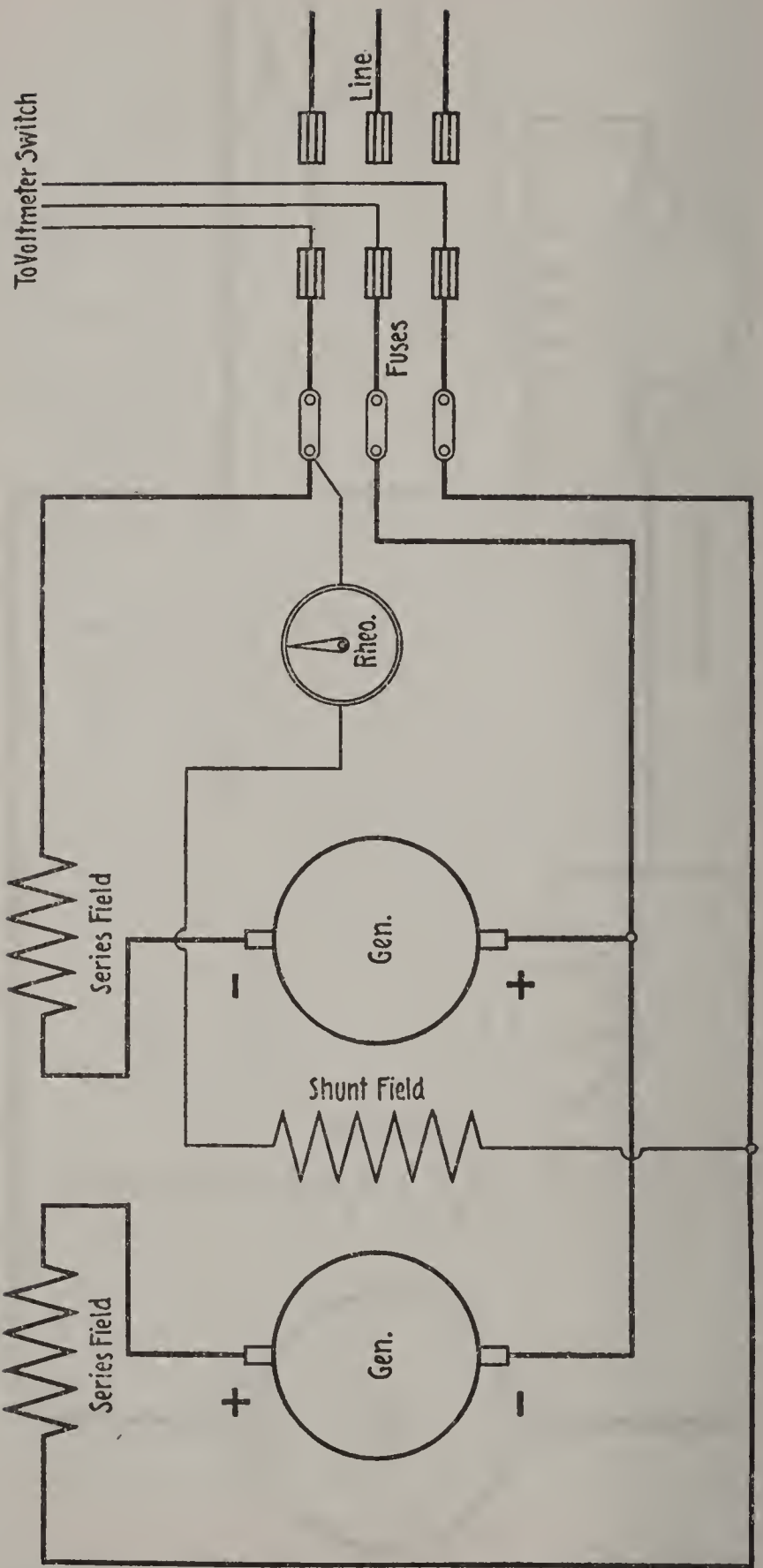

Fig. 3. Coin Collector Generator.

(See page 3)

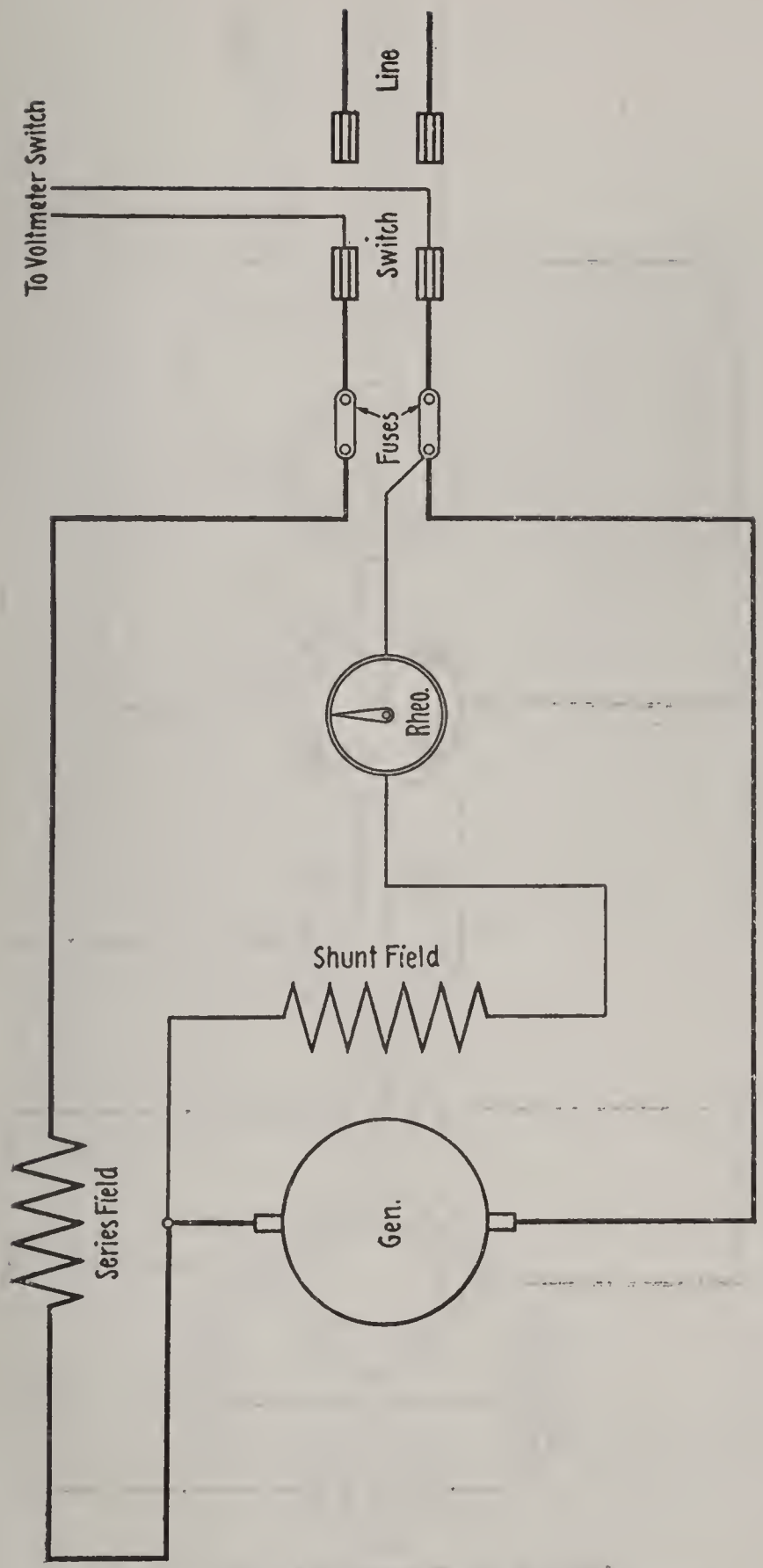

Fig. 4. Message Register Generator.

(See page 3)

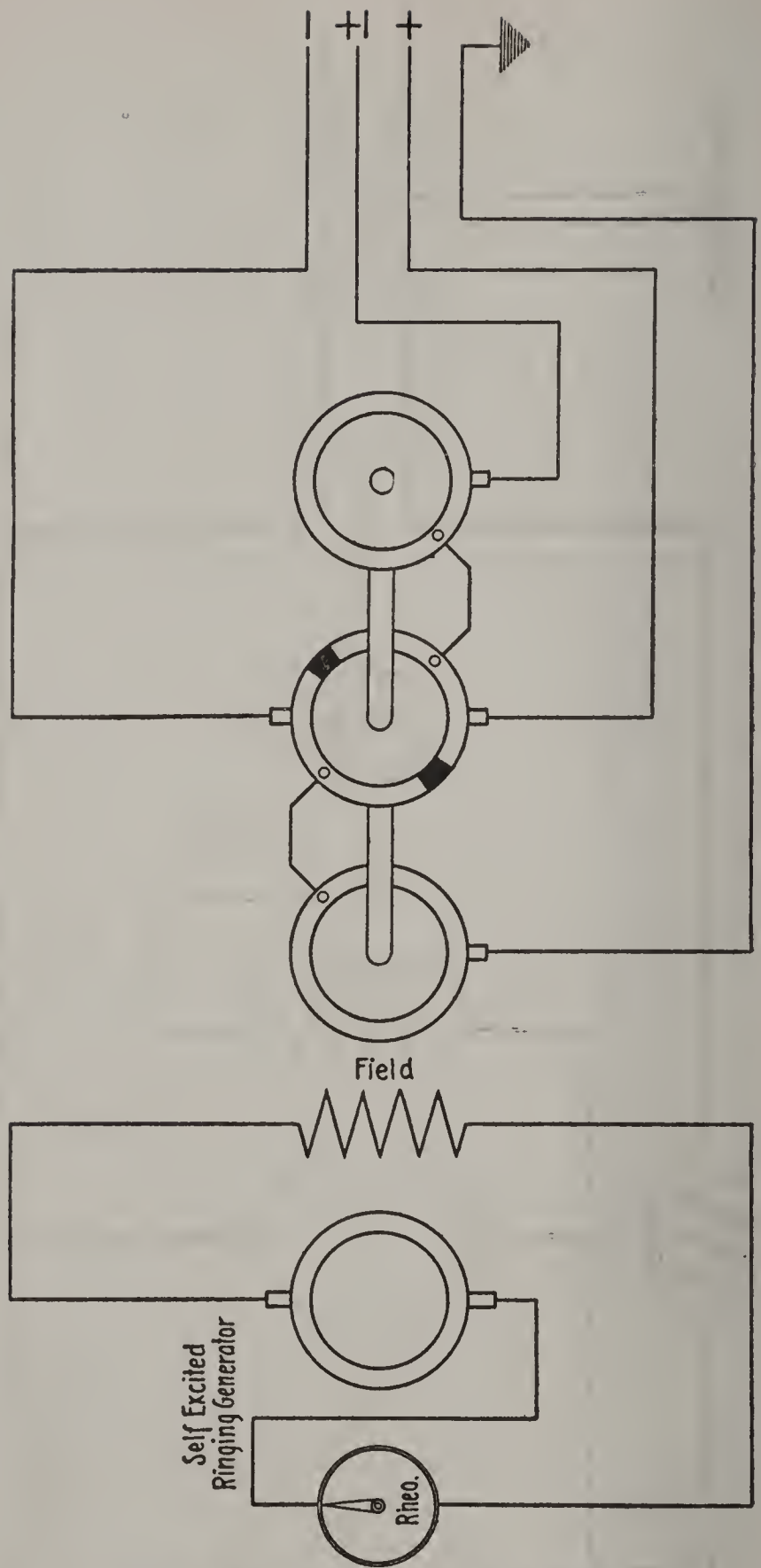

Fig. 5a. Ringing Generator.
(Alternating and pulsating ringing currents)

(See page 3)

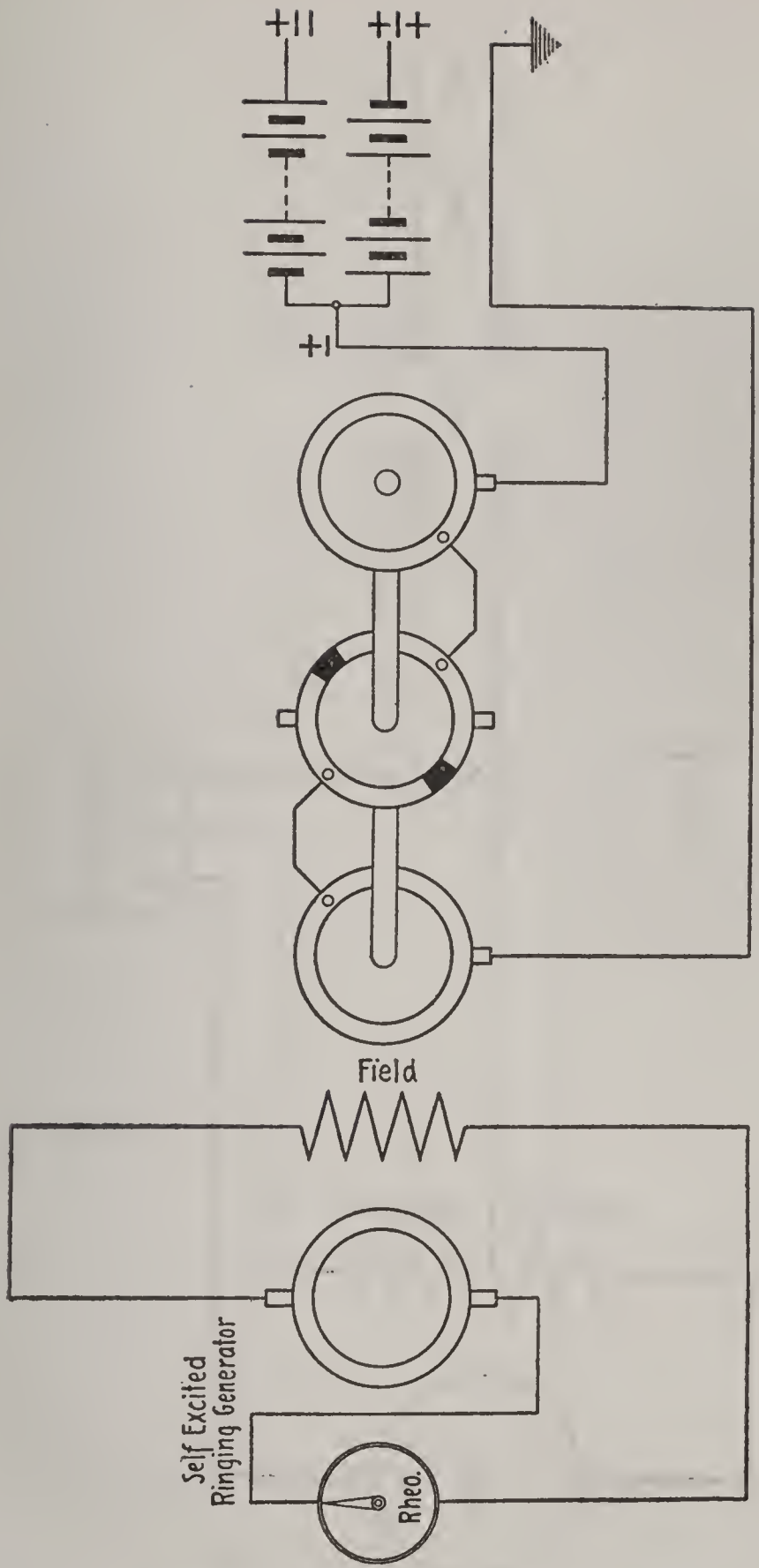

Fig. 5b. Ringing Generator.
(Superimposed ringing)
(See page 3)

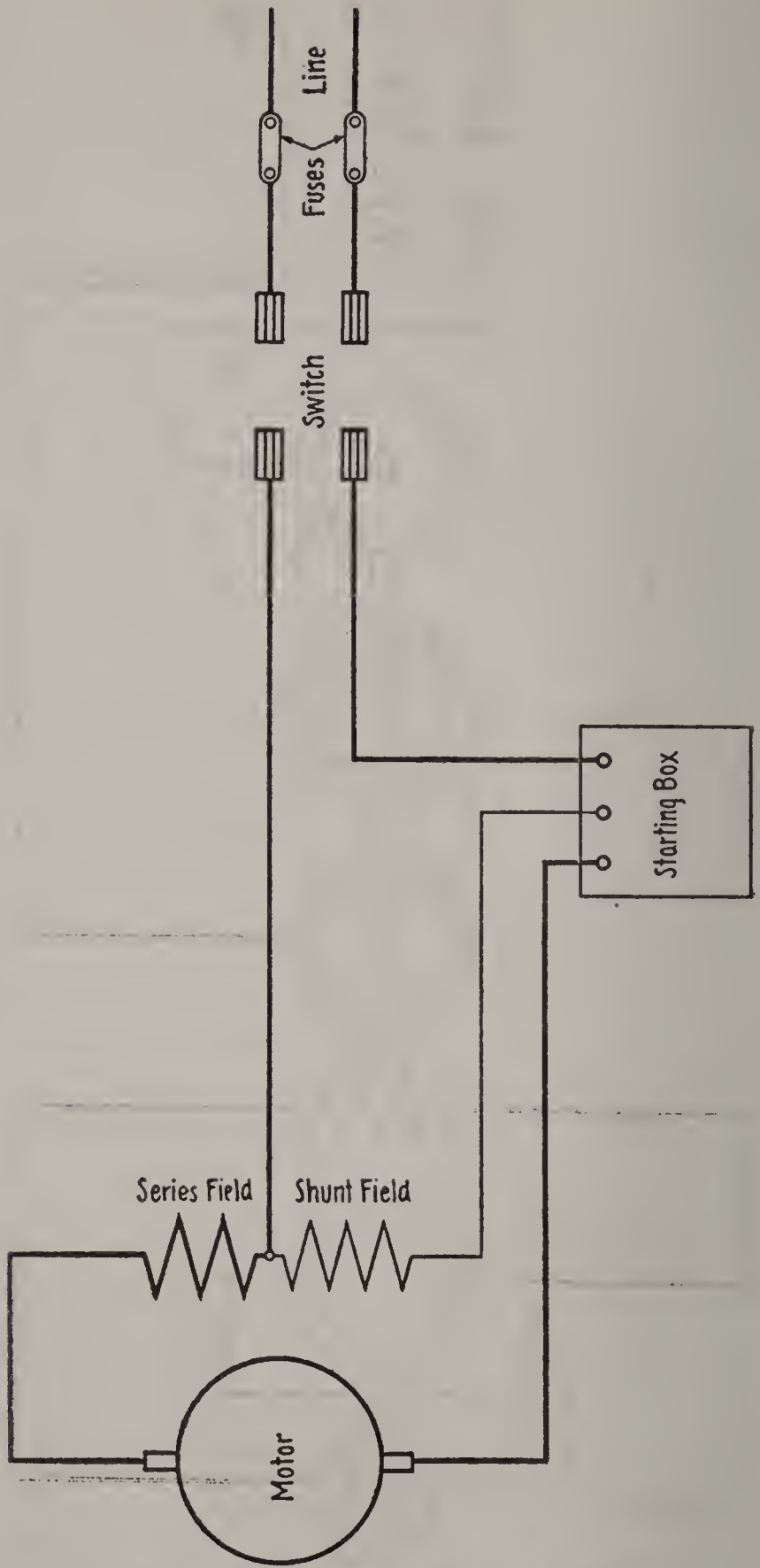

Fig. 6. Differentially Wound Motor.
(See page 4)

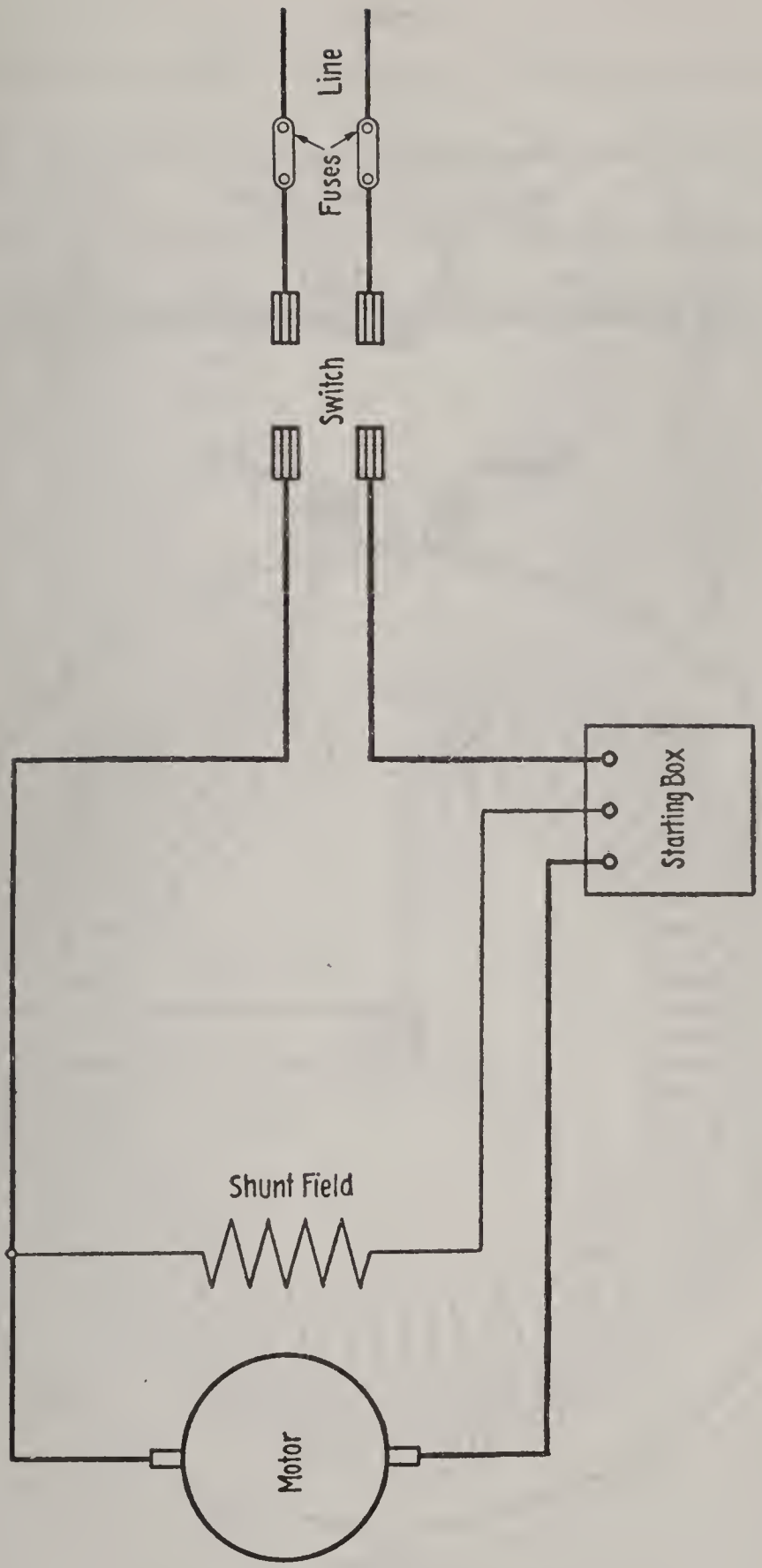

Fig. 7. Shunt Wound Motor.
(See pages 4 and 6)

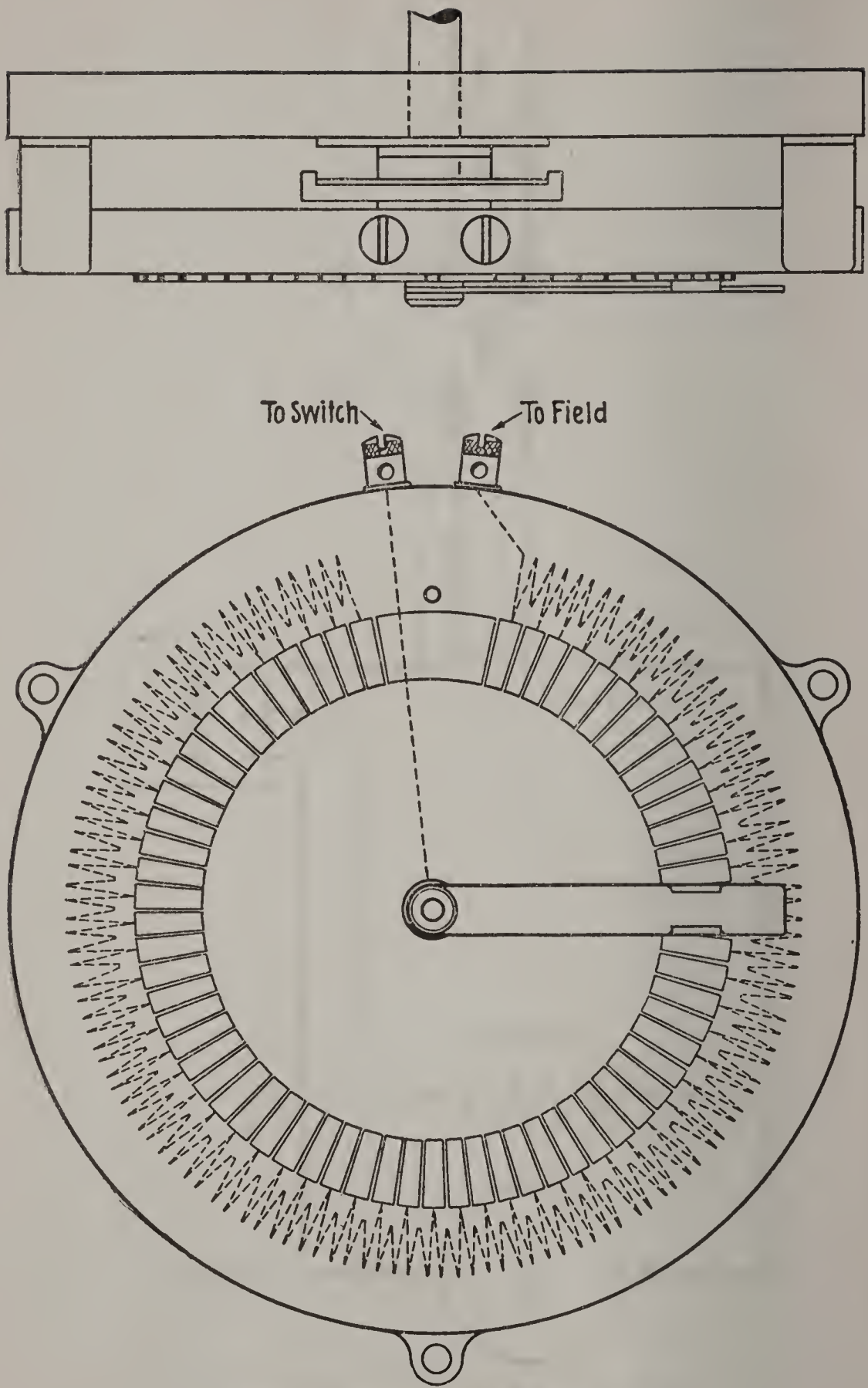

Fig. 8. Rheostat.

(See page 5)

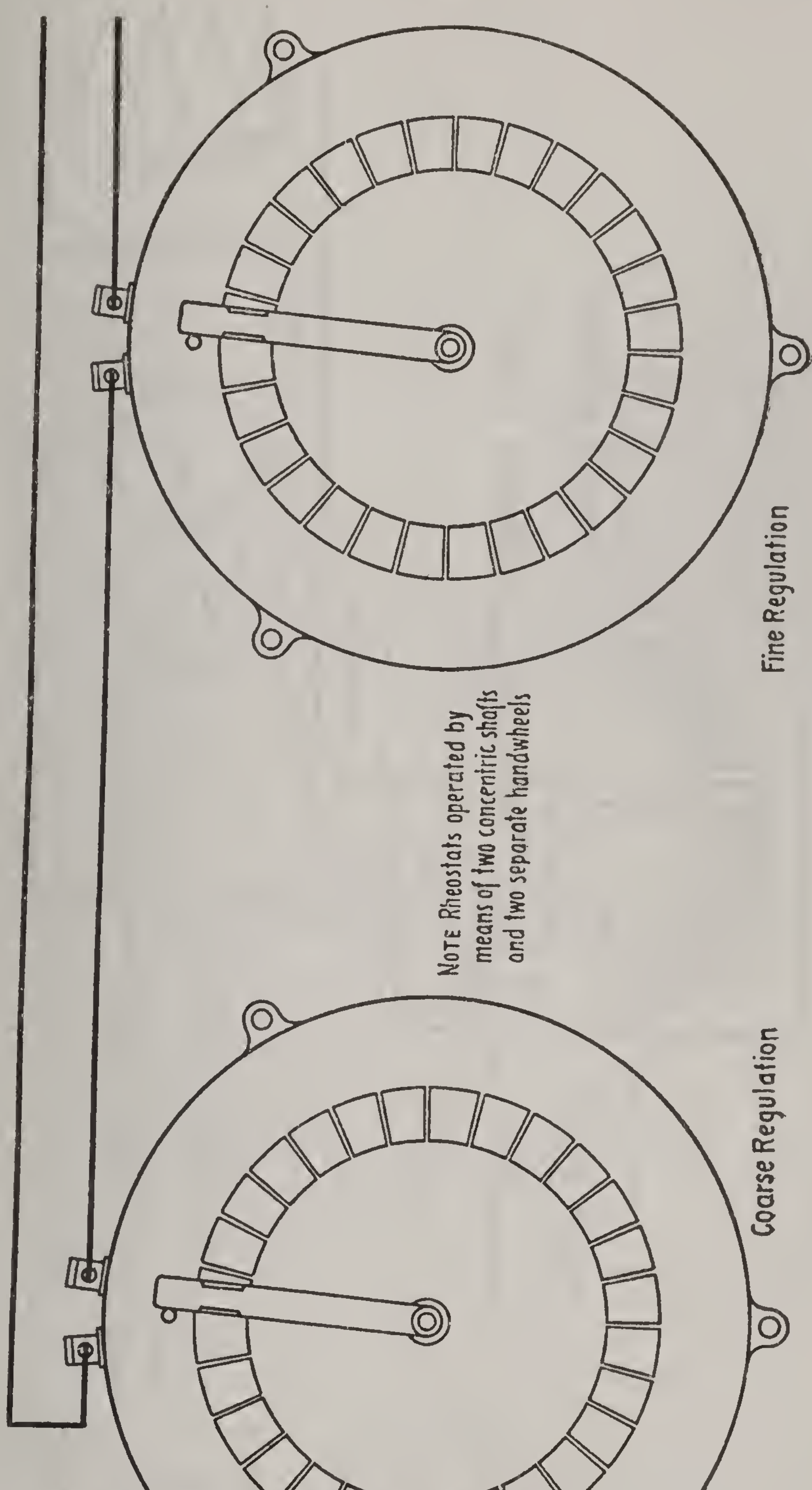

Fig. 9. Compound Rheostat.
(See page 6)

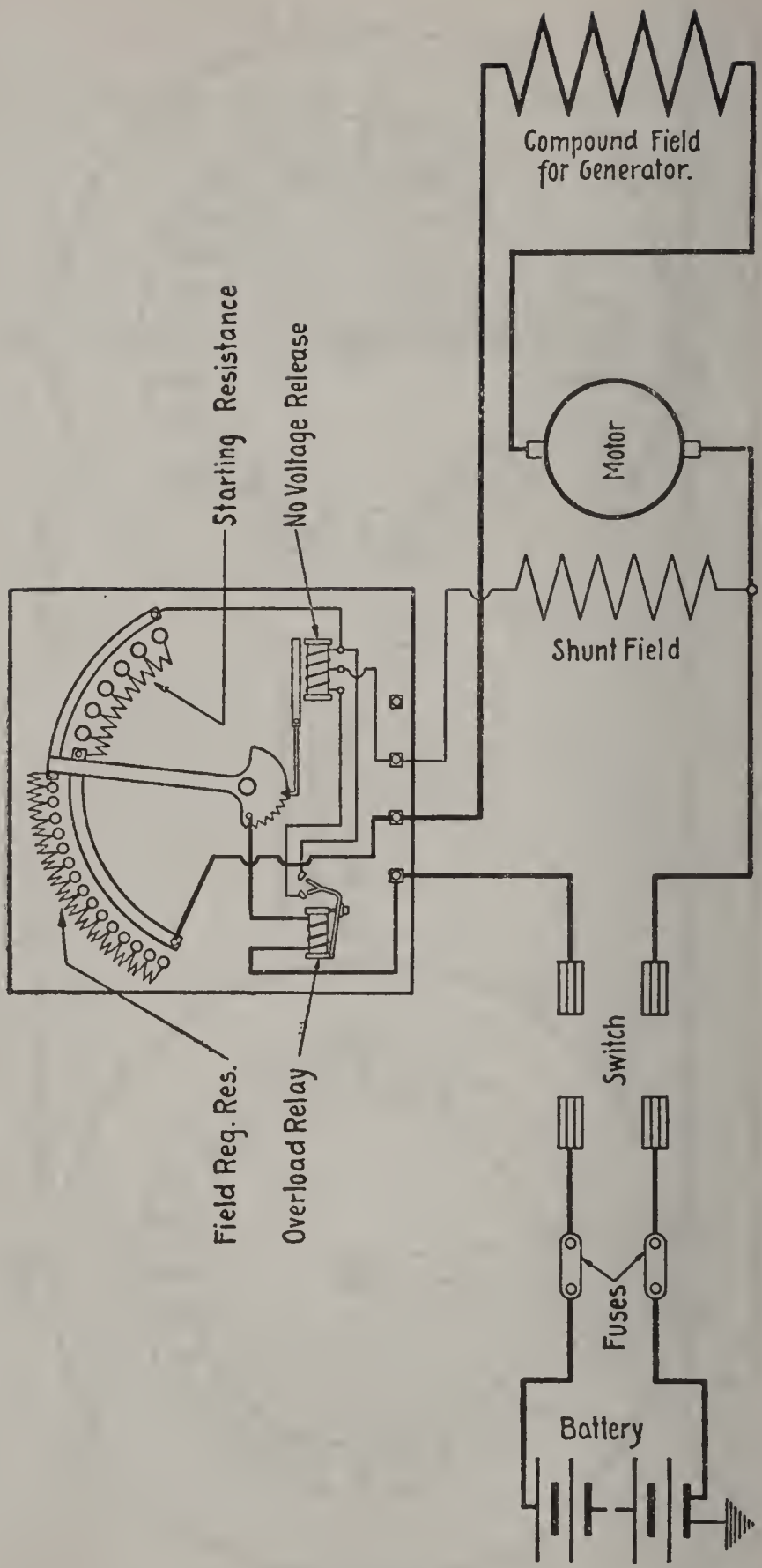

Fig. 10. Combined Starting Box and Field Rheostat.
(See page 6)

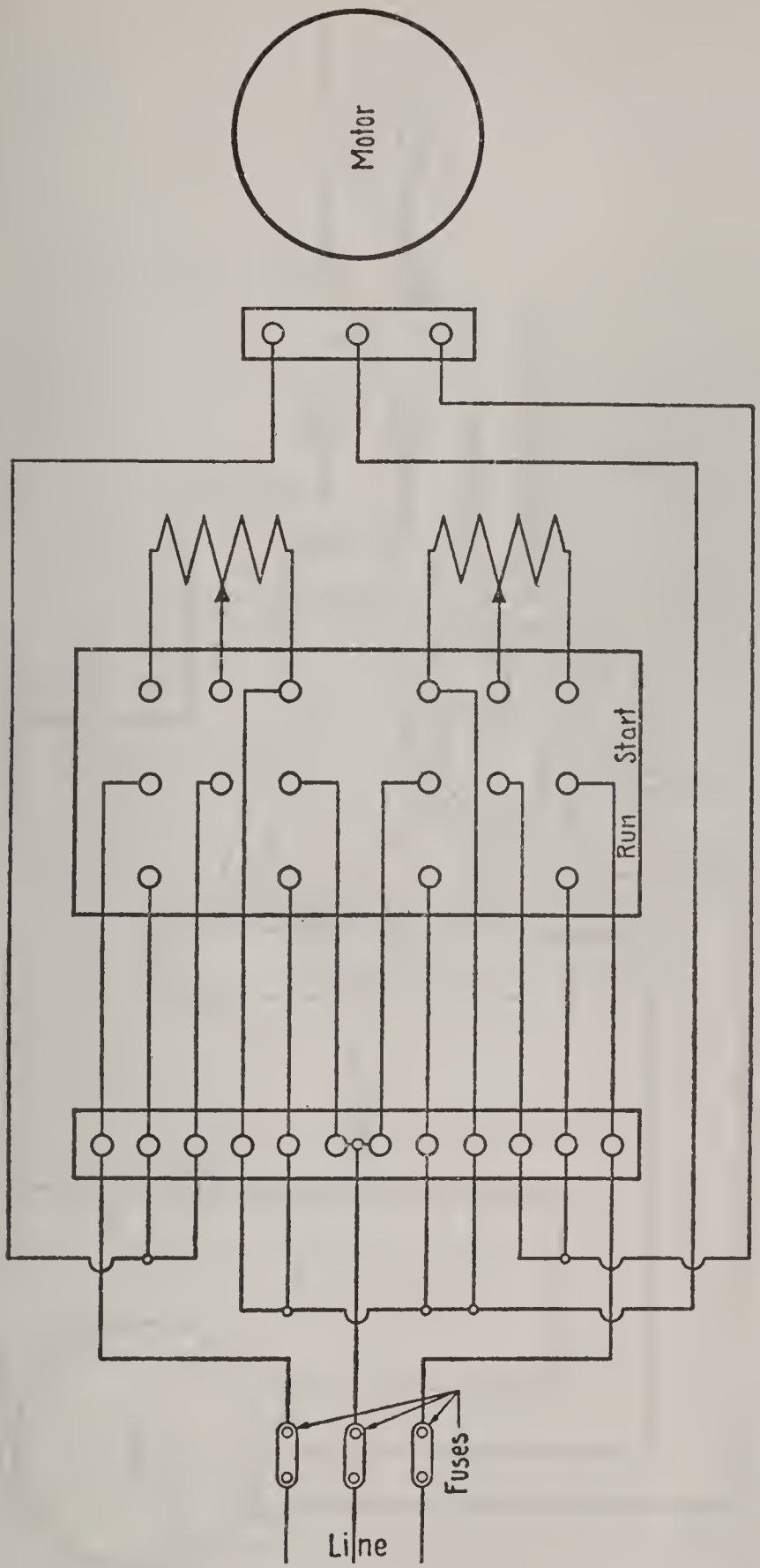

Fig. 11. Connections of Oil Immersed Auto Starter or Compensator. (2 or 3 phase motor.)

(See page 6)

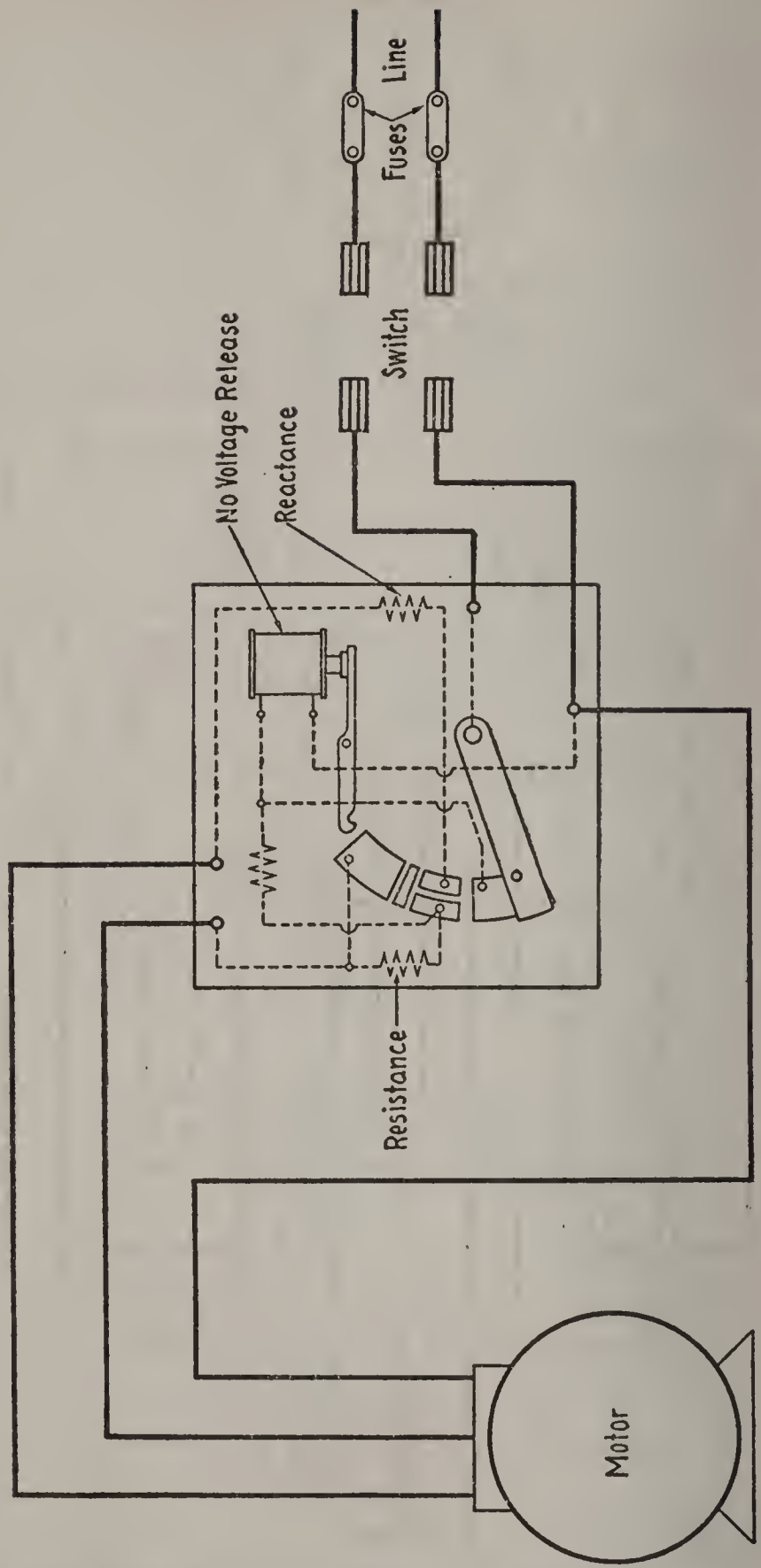

Fig. 12. Single Phase Motor with Split Phase Starting Box.
(See page 6)

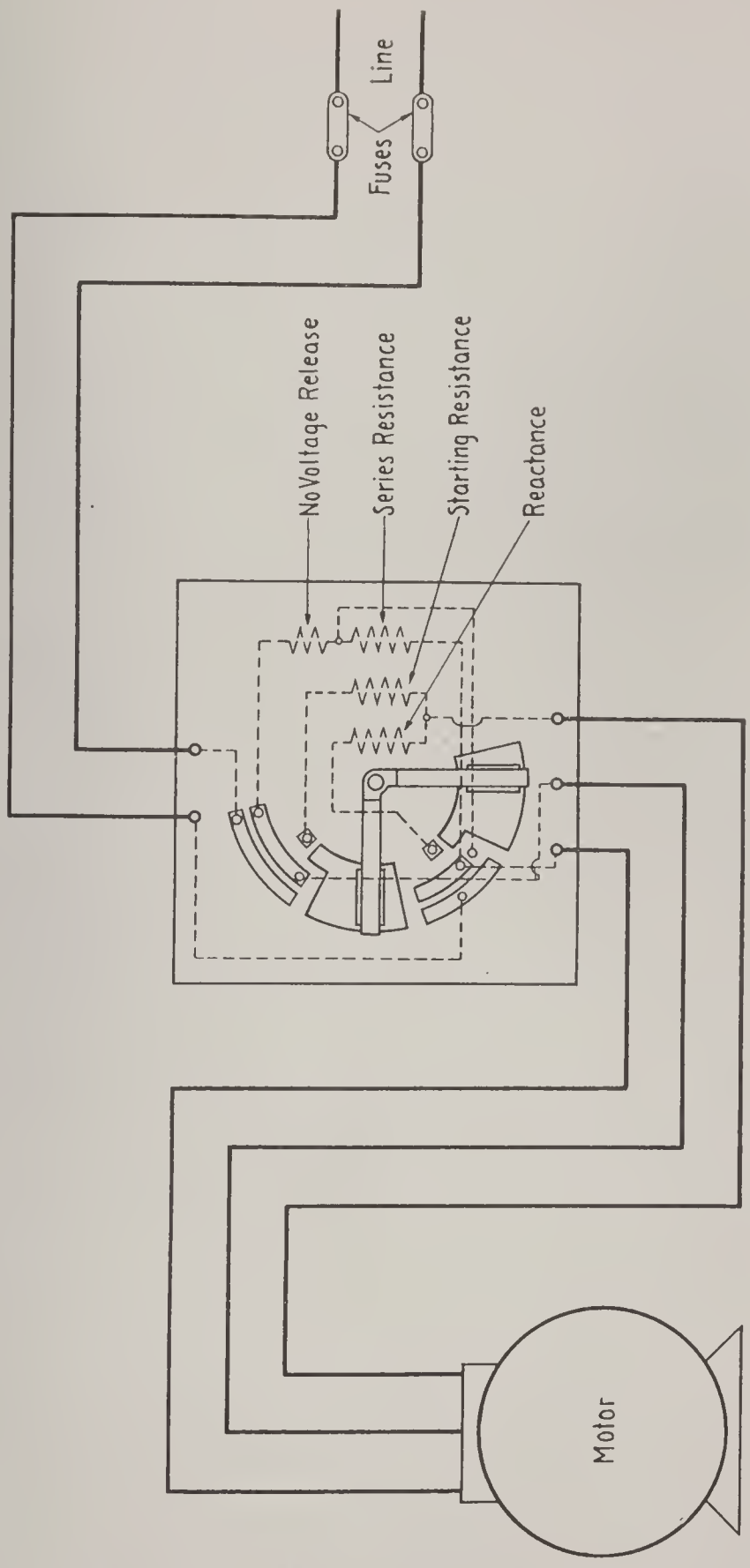

Fig. 13. Single Phase Motor with Split Phase Starting Box. (For motors of less than 1 horse power)

(See page 6)

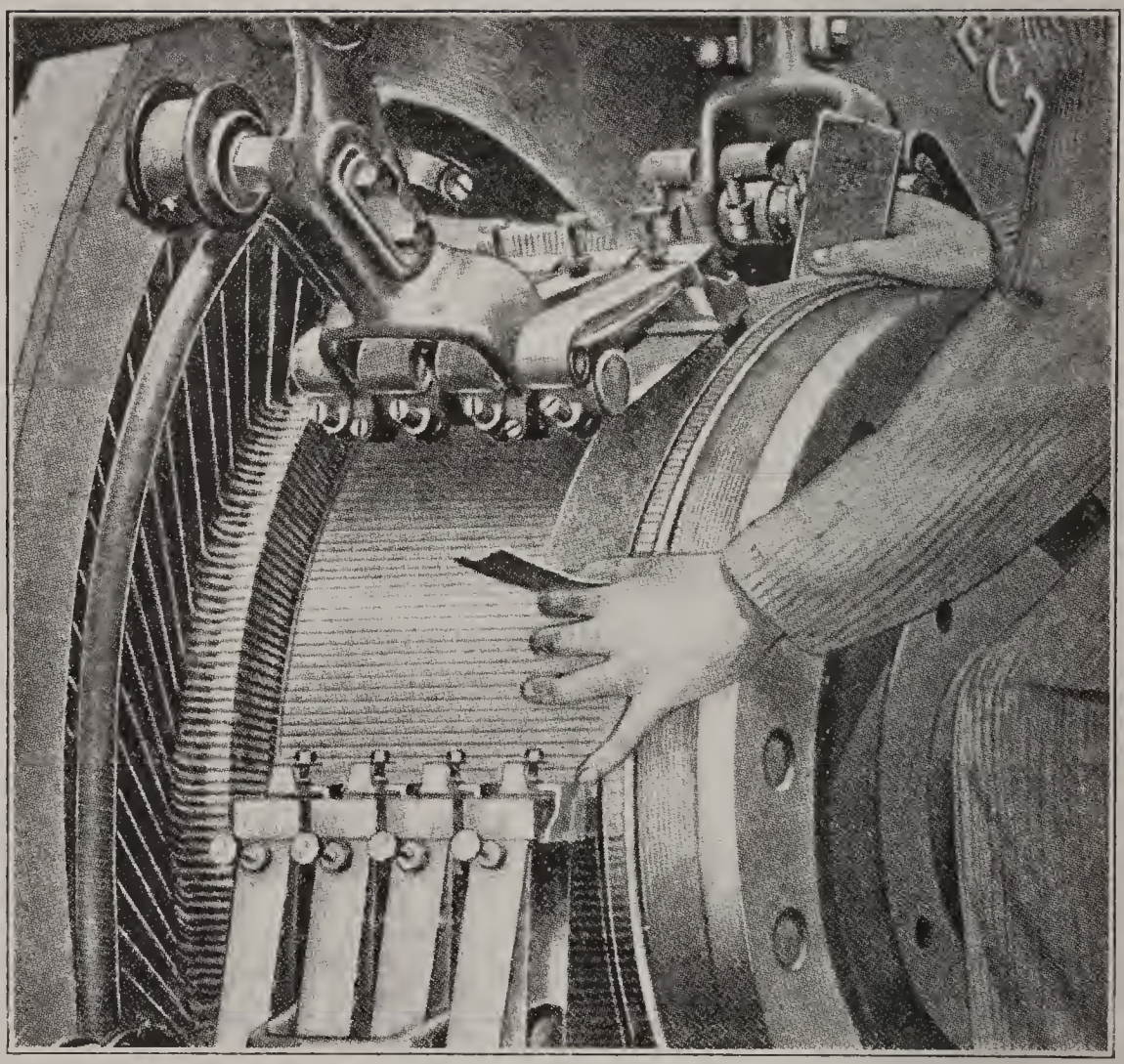

Fig. 14. Seating Carbon Brushes.
(See page 22)

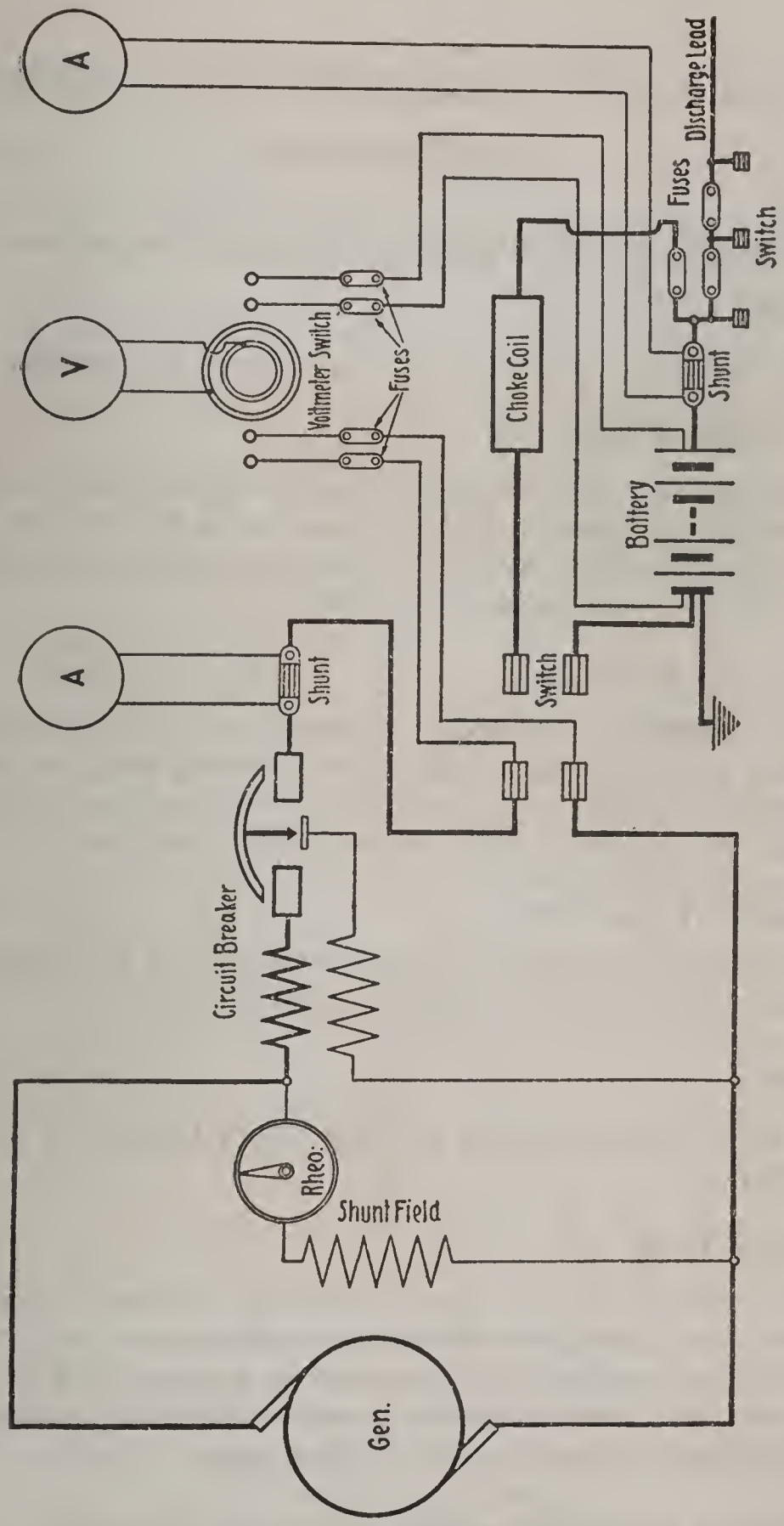

Fig. 15. Charging Circuit.

MERCURY ARC RECTIFIER SETS

DEFINITIONS

Anode

The terminal at which the current enters the rectifier tube.

Cathode

The terminal at which the current leaves the rectifier tube.

Compensating Reactance

The reactance coil connected directly across the alternating current supply leads to maintain the arc in the rectifier tube. This reactance also serves to obtain an approximate adjustment of the a.c. voltage and current.

Controlling Reactance

The reactance connected in series with the alternating current lead for regulating the alternating current voltage supplied to the tube. Indirectly, it also regulates the direct current voltage while the rectifier is in operation.

Insulating Transformer

A one to one or two to one transformer used to insulate the rectifier circuit from the outside power circuits.

Rectifier

A device for converting an alternating current to a direct current.

Rectifier Tube

An exhausted glass vessel with four terminals. Two terminals are fitted with graphite electrodes and are termed anodes, one terminal is immersed in mercury and is called the cathode, the remaining terminal is also immersed in mercury and is used for the starting anode.

Regulating Compensator—See Controlling Reactance

DESCRIPTION

A Mercury Arc Rectifier Set Consists Essentially of:

1. A rectifier tube, which contains a small quantity of mercury in vacuum and has four terminals. (See page 51)
2. A compensating reactance.
3. An insulating transformer.
4. Switches; circuit breakers; resistances; choke coil, etc., varying with the type of rectifier.

The action of the Mercury Arc Rectifier is based on the fact that the mercury in the rectifier tube when in a state of excitation gives out mercury vapor. This vapor affords a path for positive current to the mercury; but, if the current is reversed, the excitation ceases.

The tube is provided with two terminals (or anodes) which connect with the two sides of the alternating current supply lead; and, consequently, when the supply current alternation makes one anode negative, the other anode becomes positive, and vice versa.

The excitation of the mercury would not continue, however, unless some means were provided to maintain the current flow when the positive wave at one anode has decreased and is reversing and increasing to a positive wave at the other anode. The means provided consists of a compensating reactance coil bridged across the anodes—the battery under charge being connected between the mercury terminal (or cathode), and the middle point of the reactance coil. As the current alternates, first one anode and then the other becomes positive. The current flows from the positive anode through the mercury vapor to the mercury terminal, thence through the battery and one-half of the reactance coil to the opposite side of the supply lead, completing the circuit.

Half of the compensating reactance is charged while this current flows through it, and, while the polarity of the alternating wave is decreasing, reversing and increasing to the opposite polarity, the reactance discharges.

In this way, the reactance continues the current flow neces-

sary to maintain the arc in the rectifier tube until the voltage of each positive wave is high enough to maintain the current against the counter e.m.f. of the battery. It also increases the current value by means of the auto transformer action between the two halves of the reactance coil.

To start the operation of the rectifier, a switch is provided to establish a temporary shunt circuit which is closed by a mercury bridge between the cathode and starting anode when the tube is tilted. When this bridge is made and broken by rocking, arcs are formed which vaporize sufficient mercury to start excitation. The alternate paths followed by the charging current when the rectifier is in operation are indicated by light and heavy arrows. (See page 51)

OPERATION

A. Old Type, with rectifier tube on front of switchboard, direct current regulating resistance, direct current switch, separate load and starting switches.

To Start

1. Examine the regulating switch to see that all resistance is cut in. This will be when the contact arm is on the extreme left contact.
2. Remove insulating fibre stops from switch jaws.
3. Close the alternating current switch.
4. Close the direct current switch.
5. Close the circuit breaker.
6. Close the starting switch.
7. Rock the tube gently with the hand. One flash should be sufficient to start the tube, but in cold weather more may be necessary.
8. When the arc has started, wait about thirty seconds, then close the load switch.
9. Open the starting switch.
10. Adjust the direct current regulating resistance until the proper current is obtained.

To Stop

1. Open the alternating current switch.
2. Open the direct current switch.
3. Open the load switch.
4. Trip the circuit breaker.
5. Cut in the direct current regulating resistance.
6. Replace insulating fibre stops in switch jaws.

B. Old Type, with single regulating switch.

To Start

1. Examine the regulating switch to see that all reactance is cut in. This will be when the contact arm is on the extreme left contact.
2. Remove insulating fibre stops from switch jaws.
3. Close the alternating current switch.
4. Close the circuit breakers.
5. Hold the starting switch in the lower (starting) position.
6. Rock the tube gently by means of the hand-wheel on the front of the board. One flash should be sufficient to start the tube, but in cold weather it may be necessary to hold the starting switch in the lower position for about thirty seconds.

   NOTE: This time should not be exceeded as starting resistance may be damaged.
7. Adjust the hand-wheel of the regulating reactance switch until the proper charging current is obtained.
8. Restore the starting switch to the upper position.

To Stop

1. Open the alternating current switch.
2. Trip the circuit breaker.
3. Cut in the regulating reactance.
4. Replace the insulating fibre stops in switch jaws.

C. New Type, with coarse and fine regulating reactance switch.

To Start

1. See that coarse regulating reactance switch is in proper position corresponding to desired direct current voltage.
2. See that fine regulating reactance switch is in proper position, as left from previous charge. If doubtful, cut in all reactance by moving down the fine regulating switch as far as it will go.
3. Remove insulating fibre stops from switch jaws.
4. Close the alternating current switch.
5. Close the circuit breakers.
6. Hold the spring switch in the upper (starting) position.
7. Rock the tube gently by means of the hand-wheel on front of board. One flash should be sufficient to start the tube, but in cold weather it may be necessary to hold the starting switch in position and rock the tube several times.
8. Remove hand from spring switch, which will automatically throw into the lower (operating) position.
9. If necessary, adjust the charging current to the desired amperage by moving the fine regulating switch.

To Stop

1. Open the alternating current switch.
2. Trip the circuit breakers.
3. Replace insulating fibre stops in switch jaws.

TROUBLES

Failure to Obtain Arc may be due to:

1. Failure of outside power, open fuses, or defective transformer.

2. Cold weather; in which case efforts to start should be repeated several times as described under "To Start" for the proper type of rectifier.
3. Low Charging Voltage. This may extinguish the arc when the load is thrown in, due to the counter e.m.f. of the battery being greater than the charging voltage. If this happens, the voltage of the rectifier should be raised as described under "To Start".
4. Open circuit. Caused by spring clips becoming detached from rectifier tube terminals or wire from electrode to ferrule becoming unsoldered.
5. Open circuit. Due to defective starting anode resistance.
6. Defective vacuum of tube. This may be determined by noting the sound the mercury makes when allowed to roll gently about in the condensing chamber. If it makes a clear metallic click the vacuum is good, but if the sound is dull and the mercury sluggish in moving the vacuum is either partially or wholly destroyed.

Failure to Carry Load may be due to:

1. Drop in voltage of supply lead.
2. Deterioration of rectifier tube. This may also be indicated by the tube having a smoked appearance; a new tube will then be necessary.
3. Leaky rectifier tube. (See above—"Defective Vacuum")

Overheating of Starting Anode and Starting Anode Resistance, After Starting Switch is Opened, may be due to:

A grounded connection at some point between the starting anode and starting switch. Normally, these carry current for a few seconds only and are out of circuit while the rectifier is in operation.

CARE AND MAINTENANCE

Rectifiers shall be kept clean and in good repair at all times. Any defects, either in wiring, connections, resistances, tube or other parts shall be reported to the office.

Cleaning

Each week the set shall receive a thorough cleaning. This shall include the contacts of circuit breakers, rheostats and switches which shall be cleaned with cheese-cloth slightly moistened with kerosene oil. In some cases it may be necessary to use crocus cloth but in no case shall anything coarser be used. Special care shall be taken to protect lacquered surfaces.

Slate panels shall be cleaned periodically with bone black mixed with an approved cleaning oil.

An annual inspection shall be made during the first week in June of the oil in the oil-cooled transformer in the alternating current supply circuit. A written report of this inspection shall immediately be forwarded to the office—stating whether or not oil is at the proper height, and noting any indication of deterioration in the quality of the oil.

An annual inspection of the rectifier connections and apparatus will be made by the power plant force, who, at the same time, will attend to the transformer oil, changing oil if necessary.

A spare rectifier tube should be held in reserve, and, in case the tube in service has to be replaced by the spare tube, a new one should be ordered immediately.

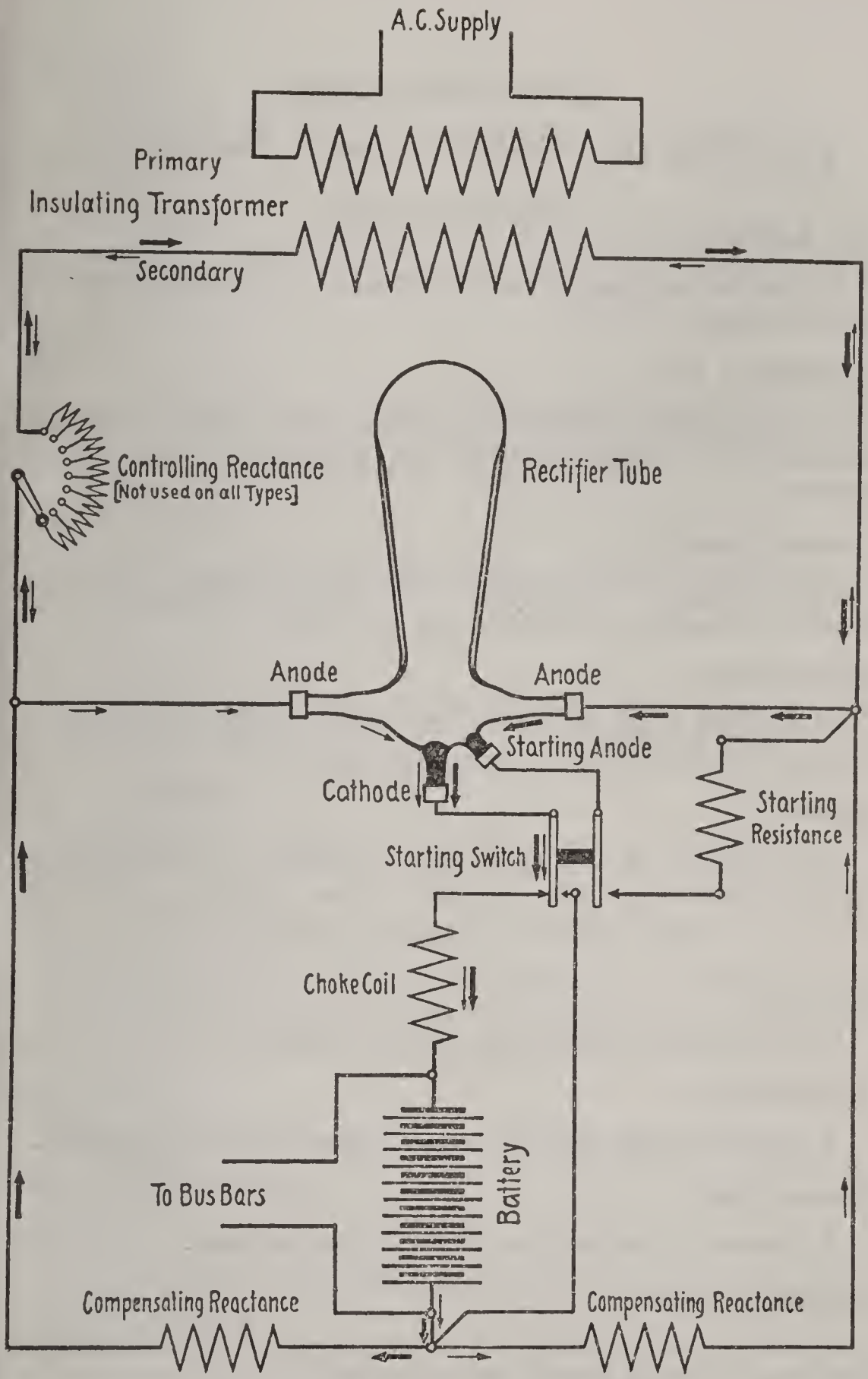

Fig. 16. Mercury Arc Rectifier.

(See pages 45 and 46)

GAS ENGINES

The White and Middleton Special Electric Type

DEFINITIONS

Air Receiver

A pipe connecting the mixing chamber with the air in the engine base.

Connecting Rod

The rod which connects the piston to the crank shaft, and changes the reciprocal motion of the piston into a rotary motion.

Cooling Chamber

That portion of the cylinder, between the inner and outer walls, in which the cooling water circulates.

Crank Shaft

A rotating shaft to which the power from the piston is transmitted by means of the connecting rod.

Cycles

The number of piston strokes between the intervals of ignition of the explosive mixture in the cylinder.

NOTE: This engine is a four-cycle engine.

Cylinder

The chamber in which the piston moves.

Exhaust Pipe

A pipe which carries the burned gases from the cylinder.

Exhaust Pot

A chamber in which the exhaust gases expand.

Expelling Valve

A valve through which the burnt gases, left in the cylinder after the working stroke, are expelled.

Equalizer

A device for regulating gas pressure. (See page 60)

Governor

A device which automatically controls the admission of the gas to the mixing chamber and thereby regulates the speed of the engine.

Igniter

A device attached to the cylinder and so constructed that an electric spark can be introduced into the cylinder for the purpose of igniting the mixture of gases.

Induction Valve

A valve through which the explosive mixture is admitted to the cylinder.

Muffler

A chamber or chambers for reducing the noise of the exhaust. (See page 64)

Mixing Chamber

A chamber in which air and gas mix before entering the cylinder.

Piston

The reciprocating part of the engine which, by means of the connecting rod, transmits to the crank shaft the power produced by the expansion of the gases in the cylinder.

Relief Valve

A valve on the outside of the cylinder which, when open, relieves compression.

Spark Coil

A coil of high inductance for producing a spark when the circuit is broken.

Water Jacket—See Cooling Chamber

DESCRIPTION

A gas engine derives its power from the expansive force of gases produced by igniting in a closed cylinder a compressed explosive mixture of gas and air. The explosion is accomplished by means of an electric spark which ignites the mixture of gas and air, and raises the temperature to about 2,700° F., thus greatly increasing the pressure. This pressure acts on a movable piston in the cylinder and converts the force of the gases into mechanical energy.

Starting with the piston at the head end, and the engine on the dead centre, as the balance wheels are revolved the piston moves toward the crank end and thus produces a vacuum in the cylinder, which opens the induction valve drawing gas and air from the mixing chamber through port "A" and induction valve "B" into the cylinder. (See page 63) Having reached the dead centre at the crank end, the piston starts to return and thereby compresses the mixture of gas and air and closes the induction valve "B". Just before the piston has reached the end of its travel toward the head end, the igniter is operated and explodes the charge. This explosion forces the piston towards the crank end and when it has reached its extreme travel the main exhaust "F" being opened, allows a portion (about 90%) of the exploded mixture to pass from the cylinder through the main or port exhaust opening "F" into the exhaust pot, thus enabling the balance wheels to carry the engine past the dead centre and start the piston on its return toward the head end. During the return of the piston toward the head end, the expelling valve "C" is opened and the remainder of the exploded mixture (about 10%) is expelled through valve "C" and the supplemental exhaust pot "D" to the exhaust pipe, thus emptying the cylinder. As the piston leaves its extreme position at the head end, the expelling valve should close and as it starts to return toward the crank end, the induction valve again opens and the operation is repeated. It will thus be seen that there is only one working stroke for two complete revolutions, during which the following events occur:

1. Admission of explosive mixture.
2. Compression of explosive mixture.
3. Explosion of mixture (working stroke).
4. Exhaust.

The reason for carrying the major part of the exhaust through the exhaust pot and muffler is to gradually bring the burnt gases down to atmospheric pressure before discharging them into the outer air, thus reducing the noise of the exhaust.

OPERATION

Before Starting, see that:

1. Cover is removed.
2. All parts are clean.
3. Oil cups are full.
4. All parts not oiled from cups are oiled.
5. Cooling water is available.
6. Brushes on generator are raised from commutator if holder permits.
7. Punch on contact rod has side marked "Starting" up.
8. Trip dog is thrown in.
9. Battery switch is closed.
10. Oil cups are feeding.
11. Valves on service side of equalizer are open.
12. Relief valve is open.
13. Pointer on equalizer is at "On".
14. Gas valve at engine is open to starting position.
15. Piston is at head end of cylinder.

To Start

1. (a) Turn balance wheels over rapidly until explosion occurs. At starting, ignition should occur when the crank is about 12° above centre. (For direction of rotation see page 61)
   (b) If engine is equipped with an air compressor, open valve until piston reaches end of stroke, then close air valve.

2. Close relief valve slowly.
3. Close muffler and drip valves.
4. When trip dog is released, turn punch quickly so that side marked "Starting" is down. When running, ignition should occur when the crank is about 15° below centre.
5. Open valves for circulating water.
6. Lower generator brushes on commutator.
7. Open gas valve at engine to running position.

While Running, see that:

1. Cooling water circulates properly.
   NOTE: Water from the cooling chambers should have a temperature of from 150° to 170° F.
2. Oil is feeding properly.
   NOTE: Glass oil cups should feed 6 to 8 drops per minute. Cylinder oil cup should feed 10 to 12 drops per minute and should be adjusted while cylinder is hot.
3. Belt runs true on pulleys.
4. Air compressor is operated until sufficient air has been compressed in tank to start engine for another run.

Before Stopping, see that:

1. Muffler and drip valves are open.
2. Raise generator brushes if holder permits.

To Stop

1. Close valve on service side of equalizer.
2. Close valve at engine.
3. Open relief valve.
4. Open battery switch.

After Stopping, see that:

1. Oil feeds are shut off.
2. Cooling water valves are closed.
3. All gas valves are closed.
4. Piston is at end of cylinder and on compression stroke.
5. All parts are clean and all bolts, nuts and screws are tight.
6. Cover is replaced when engine is cool.

TROUBLES

Failure to Start may be due to:

1. Lack of igniting current.
2. Lack of gas.
3. Valves stuck.
4. Choked exhausts or muffler.
5. Defective igniter.

Variation of Speed or **Loss of Power** may be due to:

1. Sticking of valve in equalizer.
2. Faults in governor mechanism.
3. Poor tension of spring on gas inlet valve stem.
4. Defective wiring in ignition circuit.
5. Worn piston rings or piston.
6. Worn valves.
7. Improper adjustment of compound slide rod.
8. Improper mixture.
9. Slipping of belt.
10. Defective igniter.

Piston Sticking may be due to:

1. Gummed or carbonized oil in cylinder.
2. Defective ring or rings.

Hot Cylinder may be due to:

1. Improper lubrication.
2. Improper water circulation.
3. Carbon deposit on piston.
4. Improper mixture.

Backfiring may be due to:

1. Premature ignition.
2. Improper mixture.
3. Overheated cylinder.
4. Leaky gas inlet valve.
5. Improper tension of induction valve spring.
6. Sticking of induction valve.
7. Carbon deposit or rough surface on piston or cylinder.

Knocking may be due to:

1. Hot cylinder.
2. Improper spark adjustment. Igniter points should be set about 1/32″ apart.
3. Disarrangement of engine parts such as loose wrist pin, loose brasses or worn bearings, etc.

CARE AND MAINTENANCE

Cleaning

The engine shall be cleaned while it is warm.

Repairs

All repairs or adjustments of bearings, governor and mixing chamber valves shall be made by the power plant force or under instructions from the power plant supervisor.

Belts

Belts shall not be tightened or removed without permission from the power plant supervisor. Belts shall run so that the laps run from the pulley. (See page 62)

Oily belts may be cleaned with whiting, powdered chalk, fullers' earth or air slaked lime. Dirty belts may be cleaned with a scraper.

NOTE: Belts shall not be cleaned while in motion.

Oils

Oils for engine use shall be approved by the power plant supervisor.

Cylinder oil shall be used for the cylinder oil cup and governor gears; and dynamo oil for all other cups and bearings.

In cold weather a few drops of dynamo oil in the saucer of cylinder oil cup will aid lubrication while starting. Too high a temperature in the cylinder is liable to burn the lubricating oil. The best grades of lubricating oil commence to burn at a temperature of 400° F.

Supply oil can openings shall be suitably protected to prevent foreign matter entering.

Hot Cylinders or Bearings

Overheated cylinders or bearings shall be flushed with the proper lubricating oil until cool.

NOTE: Keep engine running slowly after removing load.

Condensation

Receptacles shall be provided to receive condensation from the muffler and drip valves.

Air Compressors

Air compressors shall be operated, while the gas engine set is being used for charging, until sufficient air has been compressed in the tank to start the engine for the next run.

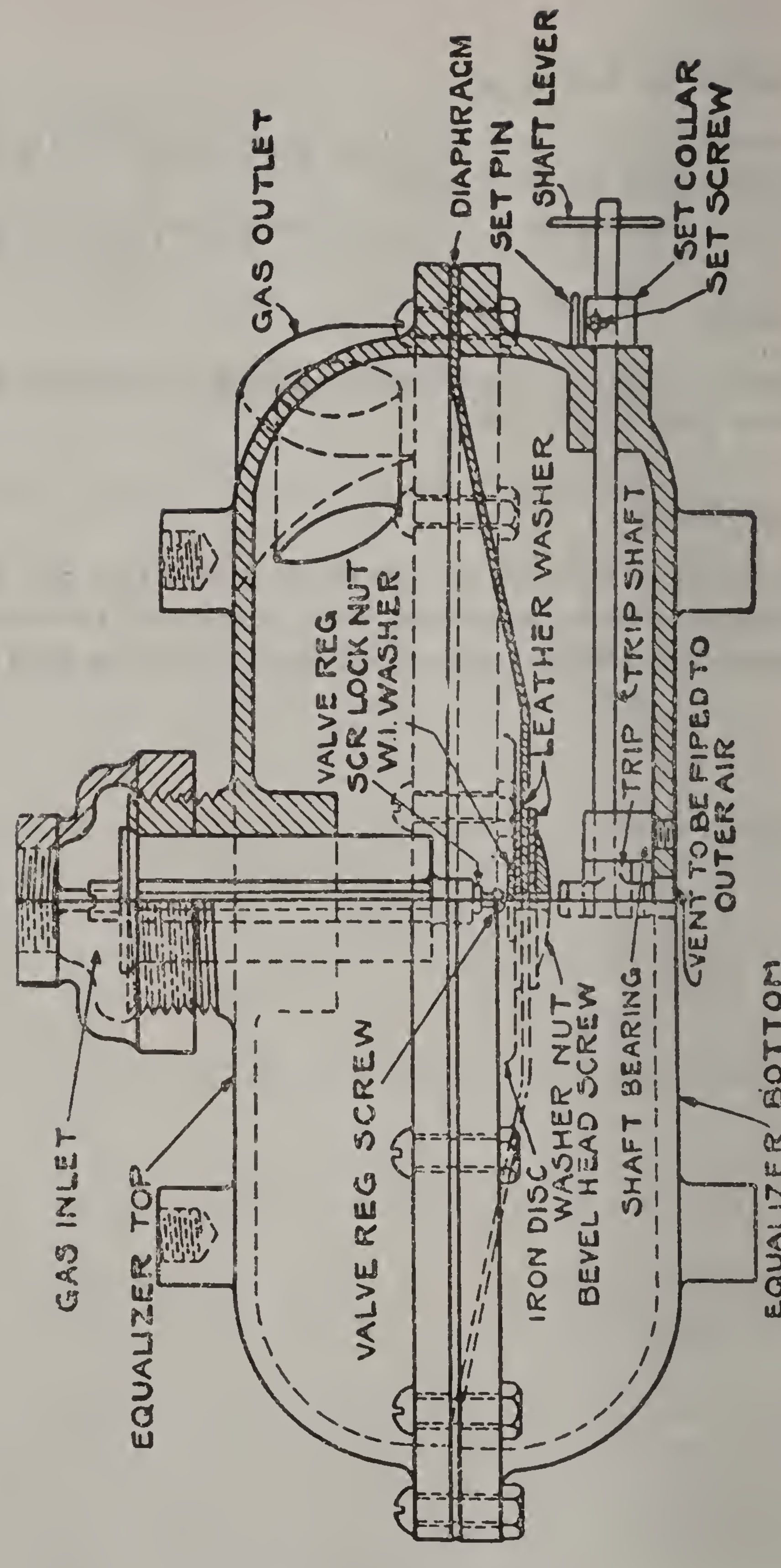

Fig. 17. Equalizer.
(See page 53)

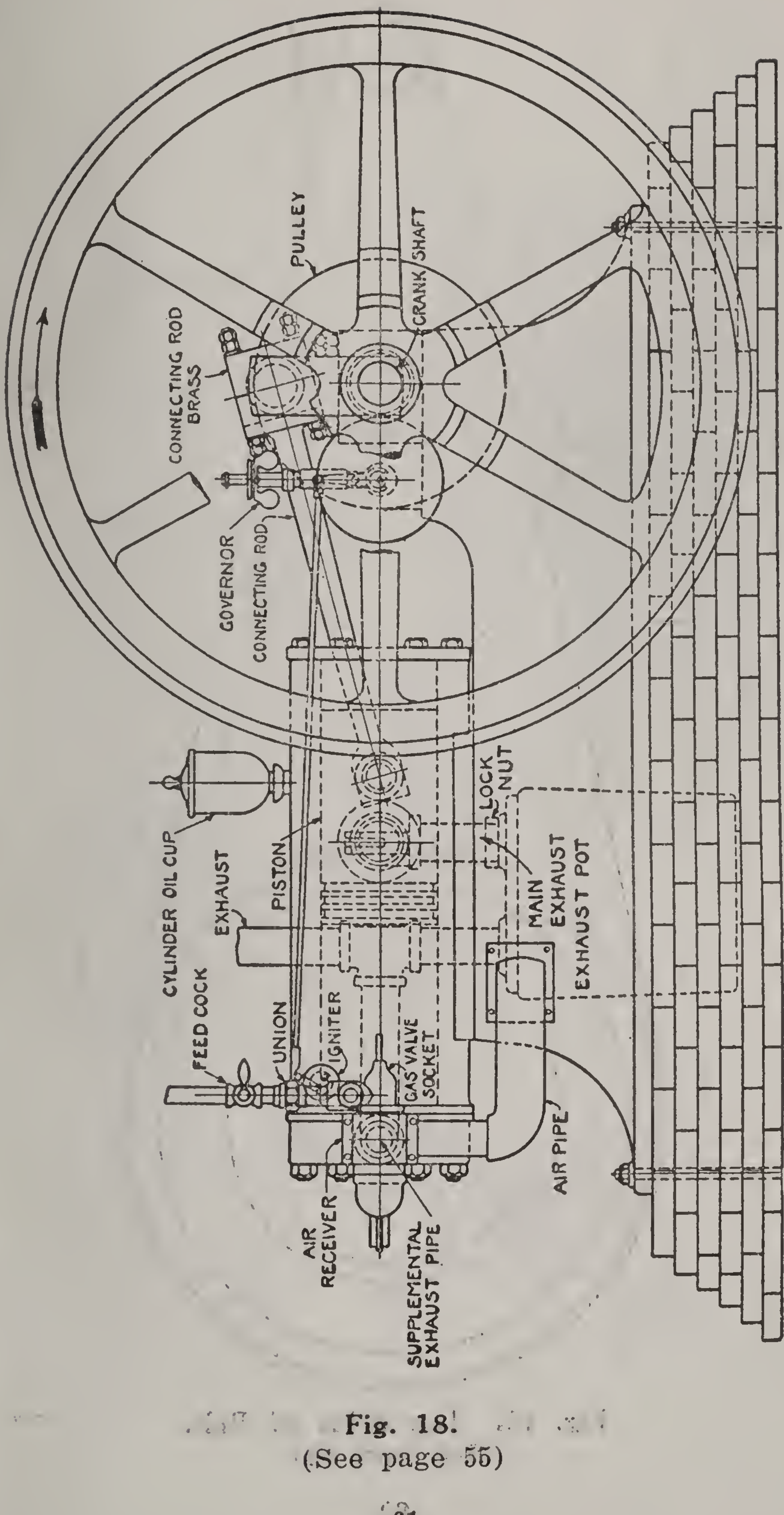

Fig. 18.

(See page 55)

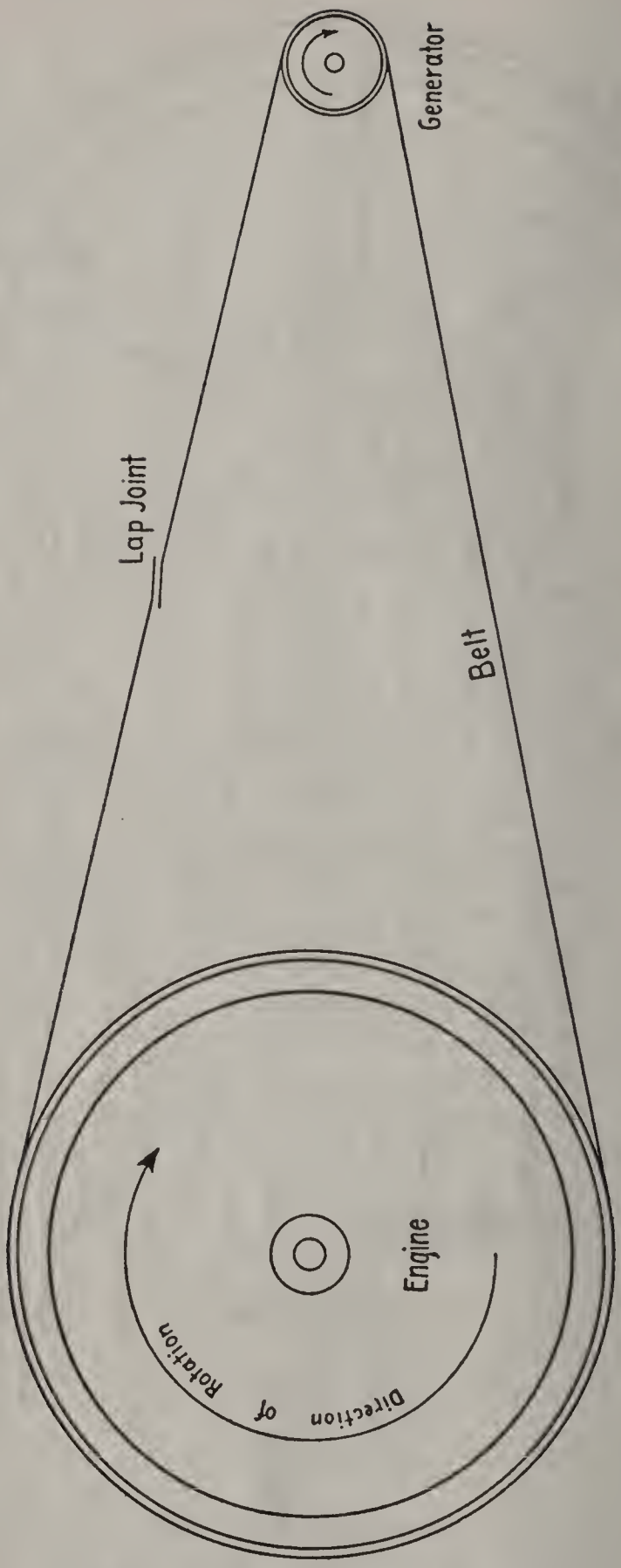

Fig. 19. Lap Joint of Belt.
(See page 58)

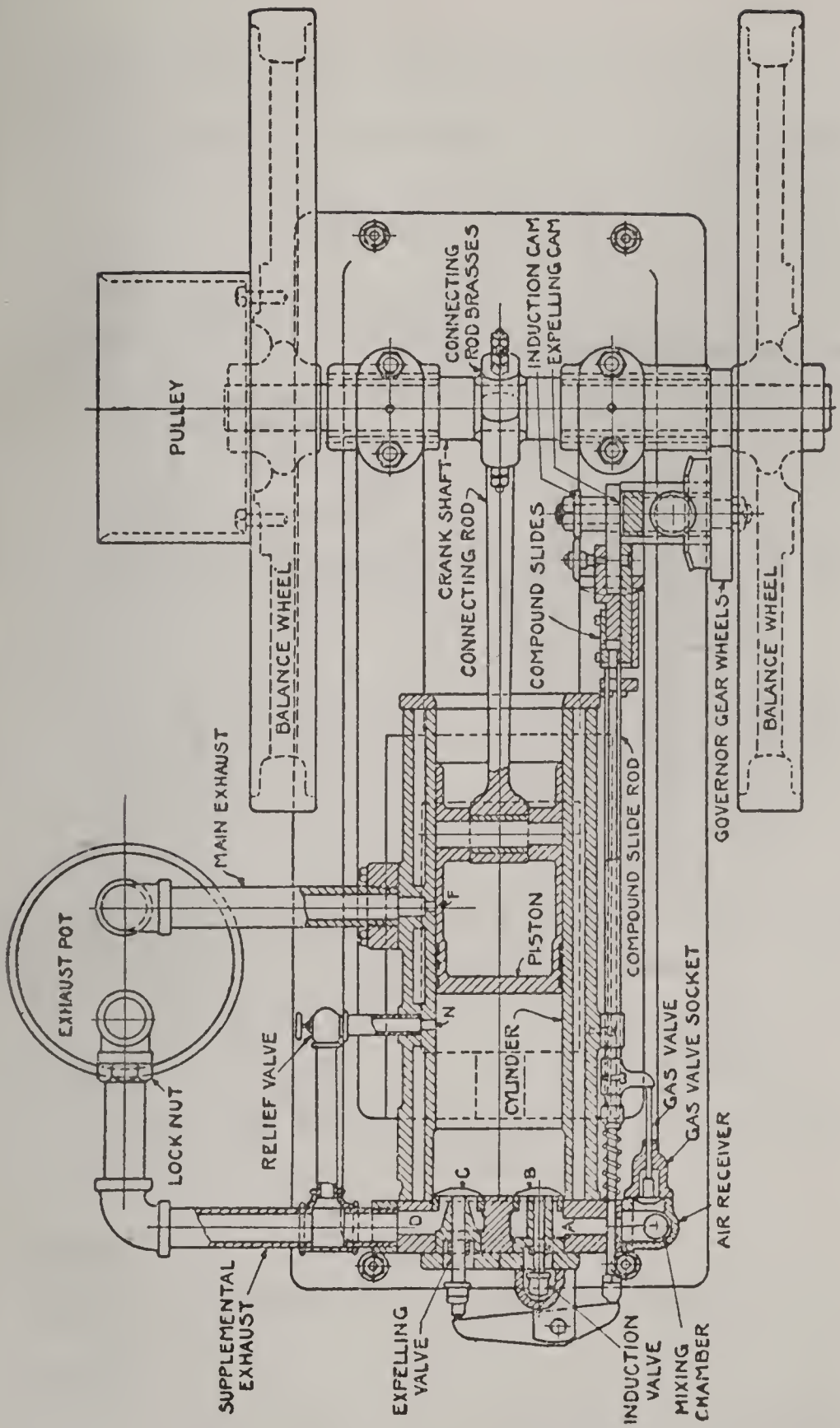

Fig. 20.

(See page 54)

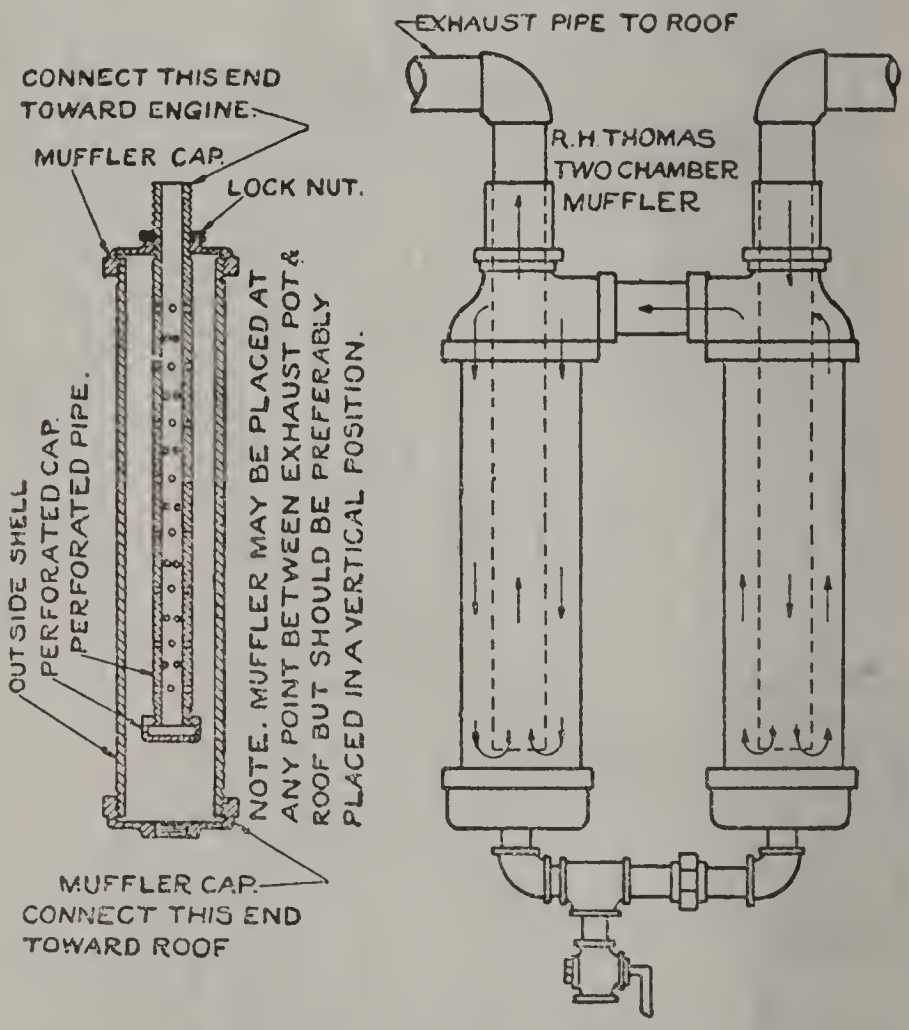

Fig. 21. Muffler.

(See page 53)

EMERGENCY CHARGING SETS

Portable Ferro Gasoline Engine Driven Generators

DEFINITIONS

Auxiliary Air Valve

An adjustable valve at the bottom of the air intake chamber of the carburetter for automatically maintaining a constant mixture at various speeds.

Carburetter

The device which supplies the cylinder with vaporized gasoline mixed with air.

Combustion

The burning of the gasoline vapor after ignition has taken place.

Connecting Rod

The rod which connects the piston to the crank shaft and changes the reciprocal motion of the piston into a rotary motion.

Cooling Chamber

That portion of the cylinder, between the inner and outer walls, in which the cooling water circulates.

Crank Case

The metal casting which encloses the crank shaft.

Crank Shaft

A rotating shaft to which the power from the piston is transmitted by means of the connecting rod.

Cycles

The number of piston strokes between the intervals of ignition of the explosive mixture in the cylinder.

NOTE: This engine is a two-cycle engine.

Cylinder

The chamber in which the piston moves.

Exhaust Pipe

A pipe which carries the burned gases from the cylinder.

Governor

A device which automatically controls the admission of the explosive mixture to the cylinder, and thereby regulates the speed of the engine.

Induction Coil

The coil which transforms the low tension battery or generator current to a high tension current.

Muffler

A chamber for reducing the noise of the exhaust.

Needle Valve

A valve on the carburetter for adjusting the proportion of gasoline vapor in the mixture.

Piston

The reciprocating part of the engine which by means of the connecting rod transmits to the crank shaft the power produced by the expansion of the gases in the cylinder.

Priming of Cylinder

Inserting gasoline to the cylinder through the cup on top.

Spark Plug

A device attached to the cylinder and so constructed that an electric spark can be introduced into the cylinder for the purpose of igniting the mixture of gases.

Timer

A device for advancing or retarding the spark, so that the mixture in the cylinders may be ignited at a desired position of the piston stroke.

Vibrator

An attachment for making and breaking the primary circuit of the induction coils.

Water Jacket—See Cooling Chamber

NOTE: For explanation of electrical terms see section on "Motors and Generators".

OPERATION

Before Starting, see that:

1. Platform of truck is approximately level.
2. Exhaust pipe is screwed into muffler.
3. Hose is connected to inlet and outlet connections and also to the water supply and that water flows properly. The inlet connection is the lower one. If a barrel is used prime the inlet hose by pouring water in it till it is full and water runs out of the outlet connection at the pump, then plunge the end of the inlet hose to the bottom of the barrel and place the outlet hose on top of the barrel in order to complete circulation of water. See that inlet connection is air tight.
4. Oil shows in oil sight gauges of generator bearings.
5. Oil is applied to the pump eccentric, timing gears and timing commutator.

6. Engine oil reservoir is full. Fill through the standpipe and close the relief valve in its cap.
7. Gasoline tank is full.
8. Generator switch is open.
9. Generator brushes raised from commutator.
10. Charging leads are properly connected to switch terminals and central office charging bus bars.
11. Ammeter and voltmeter leads are connected.
12. Leads to the plug fuse cutout are reversed IF the negative end of the central office storage battery is grounded.

To Start

1. Open water inlet.
2. Open cock in gasoline feed pipe and prime carburetter by tapping priming float spindle.
3. Open needle valve about one turn from closed position.
4. Set timer to fully retard spark, as ignition should take place later than when running.
5. Open compression relief cocks.
6. Fill priming cups with gasoline; open priming cocks and rock fly wheel to draw charge into cylinders.
7. Throw ignition switch to "B" (see designation on switch) to close dry battery circuit.
8. Close priming cocks and crank the engine.
9. The instant engine fires advance the spark and close compression relief cocks.
10. Adjust needle valve until engine fires regularly and runs smoothly.
11. Lower brushes on generator commutator.
12. Adjust field rheostat, or speed of the engine by means of the timer, until generator voltage is about one volt higher than voltage of battery.
13. Close generator switch and adjust field rheostat, timer and needle valve, until generator is delivering desired current and engine runs smoothly.
14. Throw ignition switch to "M" (see designation on switch) to connect the ignition circuit to the generator. Adjust small rheostat until engine is running

satisfactorily with the least possible sparking at the points of the vibrator.

15. Readjust, if necessary, the field rheostat, timer and needle valve until generator is delivering desired current and engine runs smoothly.

NOTE:

(a) If the desired output cannot be obtained by means of the field rheostat adjustments, it can be obtained by speeding up the engine. This is done by advancing the spark.

(b) When the engine is running, the needle valve of the carburetter should be closed as much as possible without causing back firing.

While Running, see that:

1. Cooling water is circulating.
2. All oil tubes of the engine are feeding properly
   (a) 6 drops a minute to the bearings.
   (b) 10 drops a minute to the cylinders.
   (c) 20 drops a minute to the carburetter.
3. The pump eccentric, timing gears and timing commutators are oiled every half hour.
4. Engine does not pound, miss fire or back fire; nor cylinders get too hot.
5. Gasoline tank is kept well filled.
6. Generator lubricating rings revolve properly.

To Stop

1. Reduce generator load.
2. Open main switch.
3. Shut off gasoline supply at tank and allow engine to run until the carburetter is empty.
4. Open ignition switch.
5. Open relief valve on top of engine oil standpipe.
6. Raise brushes from generator commutator.
7. Close needle valve.
8. Shut off water. In cold weather, or if set is to be moved, disconnect hose and drain all water from water jacket of cylinders.

TROUBLES

Failure to Start may be due to:

1. Lack of igniting current.
2. Lack of, or impure, gasoline.
3. Dirty spark plug.
4. Incorrect adjustment or fouling of needle valve of carburetter.
5. Ignition taking place too late—in that case advance spark slightly.
6. Excess of oil in crank case. This may be removed by unscrewing the drain plugs.

Variation of Speed may be due to:

1. Improper setting of rheostat in igniter circuit.
2. Improper setting of auxiliary air valve.
3. Too much gasoline—engine flooded.
4. Obstruction in needle valve or in vent in filling hole plug of gasoline tank.

Piston Sticking may be due to:

1. Cylinder becoming gummed from oil.
   REMEDY: Prime the top of cylinder with half a cupful of kerosene followed by a tablespoonful of cylinder oil. Then turn engine over a few times.

Hot Cylinders may be due to:

1. Improper lubrication.
2. Carbon deposit in cylinder.
3. Insufficient or clogged water circulation.
4. Retarded spark.
5. Too rich a mixture.

Missfiring may be due to:

1. Defective spark plugs.
2. Timing commutator cut or dirty.
3. Vibrator out of adjustment.

Backfiring may be due to:

1. Spark too far advanced.
2. Too lean a mixture.

Explosion in Muffler may be due to:

1. Too rich a mixture.
2. Loose connection in ignition circuit.

Engine Knocking may be due to:

1. Hot cylinder.
2. Spark too far advanced.
3. Disarranged or worn engine parts.
4. Improper mixture.

Inability to Develop Full Load may be due to:

1. Only one cylinder firing.
2. Defective spark plug.
3. Defective, or poorly adjusted, timing commutator.
4. Loose connection or open in the ignition circuit.

CARE AND MAINTENANCE

CAUTION

Gasoline is a dangerous explosive. Keep all open flames, including lanterns, away from engine!

Protection of Set

In case of rain or snow, the set shall be suitably protected.

Cleaning of Engine

At the end of each run, the engine shall be cleaned as follows:

1. Wipe all external parts clean and dry.
2. Wipe unpainted parts with waste dipped in oil.

Cleaning of Generator

At the end of each run, the generator shall be cleaned as described in the section on "Motors and Generators".

Covering

When sufficiently cool, the set shall be covered with the tarpaulin.

Hot Bearings

Throw off load, reduce speed of engine and flush bearings with oil until cool.

Master Vibrator

Turn vibrator end for end once a day, or more often, to prevent pitting of contacts.

Oil

The proper oil to be used with the engine is "Gargoyle Marine Motor Oil" or an approved equivalent.

Repairs

Repairs shall be made only under the direction of the power plant supervisor.

Before Shipment, see that:

1. Gasoline tank is empty.
2. Ignition switch is in "Off" position.
3. All tools are locked in box.
4. The two lengths of hose and the two charging leads are strapped inside the casing.
5. Ammeter and voltmeter are removed from their mounting and placed in the carrying case.
6. The two cans of lubricating oil are secured within the casing.
7. The housing panels put in place and roof locked by the two padlocks.

Mode of Shipment

Unless otherwise specified by the Division Equipment Engineer, the set shall be shipped as follows:

1. The charging set by freight.
2. The keys for the tool box, padlock, and instrument case by registered mail.
3. The instrument carrying case by express.

Tests

A complete inspection, and full load test of at least two hours, shall be made bi-monthly under the direction of the power plant supervisor. A record of each inspection and test shall be entered in a log book to be kept in the tool box. A duplicate record shall be sent to the power plant supervisor.

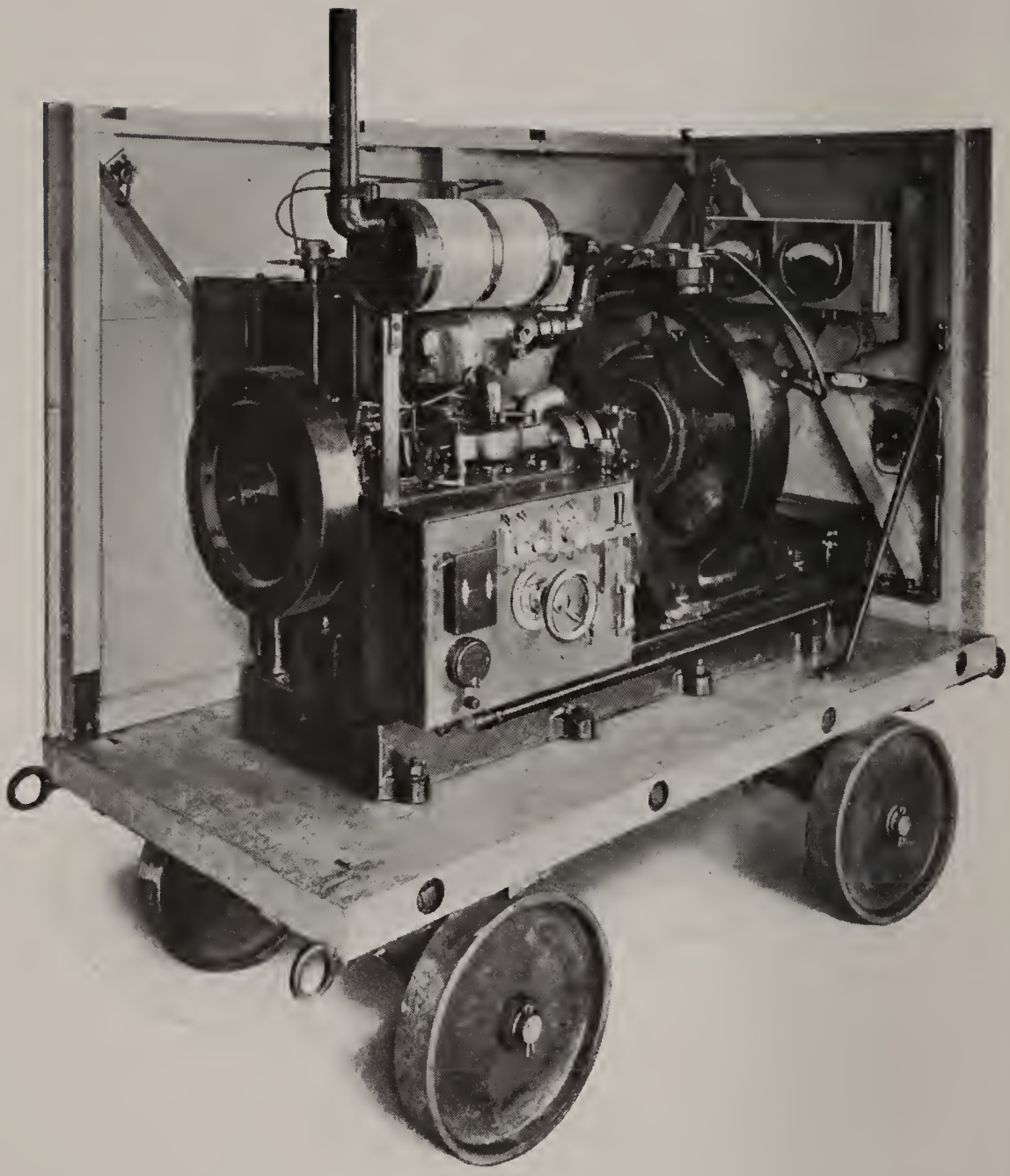

Fig. 22. Portable Gasolene Engine Driven Charging Generator.

STORAGE BATTERIES

The Electric Storage Battery Co. Type

DEFINITIONS

Battery Discharge

That portion of the load which is carried by the battery.

Bolt Connector—See Connector

Bus Bar

A lead bar, located between cells, to which the plates are burned. The terminal busses of the end cells are lead covered copper bars.

Capacity, Rated

The rated capacity of a battery is expressed in ampere hours and is equal to the normal rate in amperes, multiplied by eight (8) hours.

For example, the rated capacity of a #51-G battery is $500 \times 8 = 4000$ ampere hours.

Capacity, Reserve

The difference between the rated capacity of a battery and the actual 24-hour discharge, expressed in ampere hours.

Cell

One complete unit of a battery.

Charging Current

That portion of the generator output which is in excess of that required by the load.

Connector

A lead covered bolt, generally used on type F' and smaller cells, for connecting the elements to adjacent cells or to the external circuit.

Displacing Tank or Block

A lead alloy tank, or treated wood block, placed in the pilot cell, when not fully equipped with plates, to fill the unoccupied space.

Drip Pot

A receptacle used to collect the condensation from the vent pipe.

Electrolyte

A solution, consisting of especially pure sulphuric acid and water, in which the plates are immersed.

Floating

The battery is said to be floating when the generator output and the load are approximately equal.

Generator Output

The total current furnished by the charging set.

Hold-Down

A glass weight for holding wood separators in position.

Hydrometer

An instrument for measuring the specific gravity of the electrolyte. The specific gravity of water being taken as 1.000, a reading of 1.210 on the hydrometer indicates that the solution is 21% more dense than water.

Insulator

A glass support for tanks and wood sand trays.

Level Indicator—See Marker

Load

The current consumed by apparatus connected to the battery. The current is supplied either by battery, charging generator, or both.

Marker

An indicator to show the proper level of the electrolyte.

Pilot Cell

That cell selected by the power plant supervisor to represent the state of charge of the entire battery.

Plate, Positive

A plate of dark brown color consisting of buttons of active and reserve material supported in a lead alloy grid.

Plate, Negative

A plate of slate grey color consisting of a grid containing a number of rectangular openings filled with pure spongy lead. In the "Box Type" negative, the openings are covered with perforated lead sheets. In the "Pasted Type" negative, used with type D and smaller cells, excepting the type ET, the active material is pressed into the grid openings.

Plate Support

A sheet of glass, used with type F and larger cells, to hold the plates in position.

Sand Tray

A wood or glass tray filled with sand on which the glass jar rests.

Sediment—See description on page 80.

Separator

A specially treated wood diaphragm equipped with dowels, or a glass tube or a rubber strip, used to keep the plates from coming in contact with each other.

Sulphation—See description on page 80.

Terminal Cup

A lead coated connector, provided on end bus bars, into which the conductors are sweated.

Vent Pipe

A lead or terra cotta duct for carrying the fumes from the battery room or casing to the outside air.

DESCRIPTION

Storage or secondary batteries, also called accumulators, consist of cells in which a chemical change is brought about by passing an electric current through them, thereby rendering them capable of giving back electrical energy by discharging them until they return to their previous chemical condition.

Each Cell of a Storage Battery Consists Essentially of:

1. A negative group of plates (one or more).
2. A positive group of plates (one or more).
3. A lead lined wood tank or glass jar.
4. The electrolyte or solution.

Electrolyte

The electrolyte in a cell in good condition, at full charge and at normal temperature, should have a specific gravity of about 1.210. While charging, the specific gravity rises;

and while discharging, it falls. As the change is proportional to the ampere hour charge or discharge, the specific gravity readings are used to indicate the state of charge or discharge. To eliminate errors, due to changes in temperature, specific gravity readings are taken with a hydrometer which is correct at 70° Fahrenheit and readings taken at other temperatures are corrected to that standard. It is important that the volume of electrolyte should be maintained constant, in order that specific gravity readings may be properly compared, and for this purpose water must be periodically added as described on page 85. This is especially important in the pilot cell, as a difference of less than ⅛″ in the level may make a difference of over an hour in charging.

Chemical Action During Discharge

The sulphuric acid in the electrolyte combines with the metallic lead in the negative plates, and with the peroxide of lead in the positive plates, forming lead sulphate on both plates. This form of sulphate is harmless and invisible. The separation from the electrolyte of the sulphuric acid, which enters into the formation of the lead sulphate, causes the lowering of the specific gravity during discharge.

Chemical Action During Charge

The chemical action which takes place while the battery is being charged is approximately the reverse of the above. The action of the electric current decomposes water in the electrolyte, the oxygen combining with the lead sulphate in the positive plates to form lead peroxide and sulphuric acid, and the hydrogen going to the negative plates, breaking up the lead sulphate into sulphuric acid and metallic lead. Thus, the active material becomes lead peroxide in the positive plates, and spongy pure lead in the negative plates. The decomposition of the water and the liberation of the sulphuric acid, caused by the conversion of the lead sulphate on both plates, causes the rise of specific gravity during charge.

Formation of Gas

As the cell approaches the charged condition, the active material becomes changed, as described above, and cannot absorb all of the hydrogen and oxygen produced. The excess passes off in the form of gas.

Sulphation

During the discharge, sulphate of lead is being formed, as explained under "Chemical Action". If the cell is permitted to stand discharged for some length of time, is habitually undercharged, or otherwise neglected, the sulphate reaches a condition where it tends to fill the pores of the plates and to make the active material dense and hard. This form of sulphate cuts out of service those portions of the plate on which it is deposited. It is this condition which is ordinarily referred to as "sulphated".

Overcharge

At regular intervals the charge is continued to a point where no further rise in specific gravity or voltage takes place. This overcharge is given for the purposes of:

1. Converting to active material any harmful sulphate that may have formed.
2. Stirring up the electrolyte thereby preventing stratification.

Variation in Specific Gravity

The actual amount of lowering of the specific gravity of the electrolyte, between full charge and complete discharge, is dependent upon the quantity of solution in the containing vessel, compared with the bulk of the plates.

When the plates are badly sulphated or a large proportion of the active material has been lost, the range in the specific gravity for a complete discharge is much reduced.

Sediment

In the normal use of a battery, active material, mostly from the positive plates, is gradually thrown off and settles

to the bottom of the cells in the form of sediment. Unnecessary overcharging, resulting in excessive gassing, accelerates the wear on the plates and consequently the accumulation of the sediment.

The sediment is a conductor and therefore must not be allowed to become so deep that it comes in contact with the bottoms of the plates, as it will short circuit them.

Temperature of Battery Room

To obtain the best results, the temperature of the battery room should be kept between 40° and 80° F. If the temperature is over 80° F. for any great length of time, the wear on the plates is excessive. If the temperature is low no harm results, but the available capacity is reduced during the period of low temperature.

Voltage

The voltage of a battery is affected by the rate of charging or discharging. For that reason, the voltage cannot be used to indicate the condition of the charge without taking into consideration the rate.

The following table gives the voltage per cell at different discharging rates below which it is not considered safe to allow a cell to drop:

Voltage per Cell	Discharging Rate
1.85	Normal
1.90	¾ Normal
1.93	½ Normal
1.97	¼ Normal

Normal Charging and Discharging Rate

The rate in amperes specified by makers of the battery as the proper rate for charging, is known as the normal charging rate and is the same as the normal discharging or eight (8) hour rate, i. e., the rate which would completely discharge a fully charged new cell in eight (8) hours.

The following table gives makers normal rate per positive plate for various types of plates:

Type of Plate	Approximate Size of Plate Not Including Lugs	Amperes per Positive Plate
G	15 5/16" x 15 5/16"	20
F	11" x 10½"	10
E	7¾" x 7¾"	5
D	6" x 6"	2½
C	4⅜" x 4"	1¼
ET	7¾" x 7¾"	4½
PT	8¾" x 5"	3
CT	5" x 5"	1½
BT	4" x 3"	¾

To find the normal rate of a battery, multiply amperes per positive plate, given in table, by the number of positive plates in a cell. For example, the normal rate of a battery type G-51, which has 25 positive plates per cell, is 25 x 20 = 500 amperes.

When 2 or more sets of cells are connected in parallel for charging, the total charging rate is the sum of the charging rates of each set.

OPERATION

The following instructions apply to central office or other batteries which are operated by the specific gravity method.

For instructions covering two plate cells, see page 88.

Charging

In general, charging shall be started when specific gravity of pilot cell is 15 points (.015) less than the last overcharge maximum.

Charging shall be started before this point is reached, if necessary, in order that at the close of the day it shall be completed, or sufficient to carry the load during the night,

so that at 8 A.M. the specific gravity of the pilot cell will not be lower than 15 points (.015) below the last overcharge maximum.

In offices having only one source of power and a single charging unit, charging may be started when the specific gravity of the pilot cell is 10 points (.010) less than the last overcharge maximum, or at such time as the power plant supervisor may direct.

During charging, the battery charging current shall be maintained as near the normal charging rate as possible. Where the generator output and load, but not the battery charging current can be read on ammeters, the proper battery charging current shall be maintained by adjusting the generator output to the load, plus the normal rate. Where the battery charging current can be read on an ammeter, it shall be adjusted to the normal rate, care being taken to see that the generator output does not exceed the rated capacity of the machine.

Except when overcharging, charging shall be stopped when the specific gravity of the pilot cell is 5 points (.005) below the last overcharge maximum. For example, if the last overcharge maximum was 1.208 charging shall be stopped when the specific gravity is 1.203; all readings being corrected to 70° F.

The temperature of the electrolyte shall be watched while charging and if it reaches 105° F., the battery charging current shall be reduced or charging temporarily stopped until temperature lowers.

Overcharging

At regular intervals, the battery shall be charged until there is no change in specific gravity of pilot cell during a period of four (4) consecutive half hourly corrected readings. This specific gravity is known as the overcharge maximum.

If the battery is charged less than six (6) times per week or is disconnected, it shall be overcharged once every two weeks.

If the battery is charged six (6) or more times per week, it shall be overcharged once each week.

Overcharge day shall be designated by the power plant supervisor.

If the battery charging current is less than the normal rate, the time covered by four (4) consecutive readings shall be extended proportionately. For example, if the current is one-half the normal rate, charging shall be continued until there is no change in the specific gravity during a period of four (4) consecutive hourly readings.

Care shall be exercised to avoid excessive overcharging as this is injurious to the plates.

Floating

If there is a possibility of the specific gravity falling during the night more than 15 points (.015) below the last overcharge maximum, the battery shall be floated after the charge is completed. All other cases where floating is necessary will be determined by the power plant supervisor. Floating shall not be commenced until fifteen (15) minutes after charging is stopped. It is understood that during this interval the charging generators shall be stopped.

While floating the battery, the generator output shall be very carefully regulated to a value approximately equal to or slightly less than the load. Allowance shall be made for fluctuations in the load, especially when it is dropping, so that no current flows into the battery. Charging at a low rate, especially when the battery is nearly or fully charged, injures the plates and shortens the life of the battery.

Hydrometers and Thermometers

Specific gravity readings of the electrolyte shall be taken with a standard hydrometer which is correct at 70° F. The gravity temperature correction scale (see page 92) shall be used to correct readings taken when the temperature is above or below 70° F. This correction may be approximately obtained by adding one point (.001) for each 3° above 70° F., and subtracting one point (.001) for each 3° below 70° F. For example, if the hydrometer reading is 1.208 at 76° F., the specific gravity at 70° F. is approximately

1.210. When a standard storage battery thermometer is used, corrections may be read from the scale direct.

The hydrometer and electrolyte thermometer shall remain in the pilot cell when not in use.

The air thermometer shall be suspended in the battery enclosure near the pilot cell but not directly above any cell.

The hydrometer shall be washed after each overcharge to remove the sediment, as this may cause false readings.

CARE AND MAINTENANCE

Watering

To compensate for evaporation and spraying, water shall be added to the cells, from time to time, to bring the level of the electrolyte to height indicated by marker. These markers are not interchangeable and are provided by the power plant supervisor. Water shall be added in accordance with the following schedule:

1. Pilot cell. Daily at 8:00 A.M.; using standard rubber funnel and tube.
2. All cells. On overcharge day and at least twice a week, immediately after charging is started; also at any time there is danger of plates being exposed.

Water added to cells, other than pilot cell, shall be distributed over surface of electrolyte.

Only water approved by the power plant supervisor shall be used. Metallic receptacles shall not be used in handling water, as any particle of metal would be injurious to the battery.

Voltage

Readings shall be taken of the total battery voltage daily (Sundays and holidays included) at 8 A. M. If this is less than 2 volts multiplied by the number of cells in the set, the voltage of each cell shall be read. If the voltage of any cell is below the minimum (see page 81), charging shall be started at once.

Semi-Annual Battery Discharge

Semi-annually, at such times and in such central offices as the power plant supervisor shall designate, the battery shall be discharged until the specific gravity of the pilot cell falls 25 points (.025), unless, before that point is reached, the voltage of any cell falls to the minimum (see page 81) or unless this requires more than 24 hours for a battery which is overcharged weekly, or 48 hours if overcharged bi-weekly. This discharge shall immediately follow an overcharge and shall be taken on the day of a Traffic peg count.

The battery driven ringing, message register, and coin collector sets shall be operated during the period of discharge.

Reports, Daily

A daily report covering the following items shall be made on form provided:

1. Name of central office, date and day of week.
2. Time charging started, battery charging current and load at that time.
3. Time charging stopped, battery charging current and load at that time.
4. Time floating started, generator output and load at that time.
5. Generator output and load each half hour during floating period.
6. Time floating stopped, generator output and load at that time.
7. Voltage of battery at 8 A.M.
8. Voltage of battery just prior to charging and just before charging is stopped.

   NOTE: Special care shall be exercised to maintain the battery charging current at the normal rate while voltage readings at the end of the charge are taken.
9. Number of cell used as pilot.
10. Specific gravity of pilot cell every hour during charging, until the gravity is within two points of end of

charge and then every half hour. In the case of an overcharge, readings shall be taken every hour until the specific gravity reaches two points below the previous overcharge maximum, and then every half hour.

11. Specific gravity of each cell just prior to charging and fifteen (15) minutes after charging is stopped.
12. Temperature of electrolyte and air before and at end of charging.
13. Special work done, irregularities or trouble.
14. On days when battery is not charged, voltage of battery at 8 A.M. and at 5 P.M., specific gravity of pilot cell at 8 A.M. and at 5 P.M.

Reports, Overcharge

A copy of report for each overcharge day shall be written in ink and forwarded to power plant supervisor. On this report shall be noted any special work done, irregularities or troubles since preceding overcharge. This report shall be approved by Wire Chief and stamped "Overcharge".

Reports, Semi-Annual Discharge

A report of semi-annual discharge covering the following points shall be made on blanks provided for that purpose:

1. Name of central office.
2. Type and number of plates per cell.
3. Rated capacity.
4. Date and time discharge started.
5. Date and time discharge stopped.
6. Specific gravity and voltage of each cell at beginning and end of discharge.
7. Half hourly readings of:
   (a) Specific gravity of pilot cell.
   (b) Total load.
   (c) Machine load.
   (d) Total voltage of the battery.
8. Total incoming calls by hours.
9. Total originating calls by hours.

Records

Daily Report, approved by Wire Chief, shall be filed for a period of one year. On the first day of each month the oldest month's record shall be destroyed, leaving a complete record for twelve (12) months in the file. The word "Overcharge" shall be stamped on the report on the day overcharge is made.

Caution

Because of inflammability of gases from the battery, a flame shall not, under any circumstances, be exposed in the battery room or battery casing.

The utmost care shall be exercised to prevent any foreign substance from falling into a cell.

When it is necessary to use metallic tools near the cells, great care should be taken to prevent short circuits. In no case shall metal tools be used in the cells.

The tops of battery cases shall be kept clear. No tools or apparatus, except accessories used in connection with the battery, shall be stored within the battery casings.

Adjustment of Specific Gravity

An adjustment of the specific gravity of each cell will be made at least once a year by adding electrolyte of 1.400 specific gravity so that specific gravity at end of overcharge will be approximately 1.210. This adjustment is necessary to replace loss of acid from the electrolyte, due to gassing and absorption by the sediment, and will be made by power plant force.

Under no circumstances shall electrolyte be added to or taken from any cell except by direction of power plant supervisor.

TWO-PLATE CELLS

Charging

Two-plate cells or couples, used for superimposed ringing are not operated by the specific gravity method on account

of the small bulk of the plates and the variation in specific gravity of the electrolyte at the different levels. The voltage method is preferable. Special charging instructions covering each case will be issued by the power plant supervisor.

Voltage

The voltage shall be noted twice weekly and action taken as per page 85.

Specific Gravity

Fifteen minutes after the end of the overcharge, specific gravity readings shall be taken of all cells.

Watering—See (2) Page 85.

Reports

A report shall be made only of each overcharge, showing:

1. Total voltage before and at end of charging.
2. Specific gravity, as explained above.

A copy of this report shall be forwarded to the power plant supervisor and the original retained in the Wire Chief's files.

TROUBLES

Emergency

A report shall be made of the following conditions:

1. Any marked variation or difference between specific gravity or voltage of any one cell during a comparatively short period.
2. Any changes in color of plates.
3. Irregularities in gassing.
4. Corrosion of metal parts.
5. Failure of electric or gas power service.
6. Inability to start charging.
7. Leaky tank.
8. Low voltage or reversed polarity of any cell.
9. Any other unusual condition.

If, from any cause, a cell should become short-circuited or completely discharged, charging shall be started at once. Cell in which trouble exists shall then be explored with a lamp provided for that purpose and trouble remedied. A report of trouble shall be made at once to the power plant supervisor and if individual charging of cell is necessary, instructions to that effect will be given.

Reversed polarity of a cell occurs only when there are several cells in series with each other, and is occasioned by complete discharge to zero followed by a charge in the reversed direction with a consequent reversal of polarity of the plates. This seldom happens except in cases where a cell loses its capacity through some accident or defect and its discharge is ended before the other cells in series with it have been completely discharged.

If a glass battery jar is cracked so that part of the electrolyte leaks out, temporary repairs shall be made by painting the crack on inside of jar with asphaltum, beeswax, paraffine or shellac, and refilling jar with electrolyte or water. If a jar is broken so that it cannot be temporarily repaired, start the charging set and adjust the generator output to carry the exchange load, then remove the electrolyte until the plates are almost entirely exposed. The cell may then be short-circuited by winding uninsulated copper wire across the cell bus bars, after which the remaining electrolyte may be drawn off. In case a jar is so broken that the battery circuit is opened, service shall be restored at once by cutting in the generator, as described above, after which the cell can be short-circuited. It is important that negative plates shall be kept wet to prevent injury due to exposure to air.

Emergency troubles shall be reported orally to the office and confirmed in writing. All other troubles shall be reported by memorandum only.

Short Circuits

The most frequent trouble is a partial short circuit in a cell. This is indicated by:

1. Absence or deficiency of gassing during overcharge.

2. Falling off in voltage or specific gravity as compared with other cells of the same battery.
3. Higher temperature than in other cells.

The cause is usually one of the following:

1. Lugs touching at top of jar or supporting plates.
2. A deposit of moss or sediment bridging across the top of plates or between the lugs.
3. Buckled plates.
4. Sediment touching bottom of plates.
5. Conducting material between plates.

Buckled Plates

This condition may be due to excessive overcharging, undercharging or over-discharging. In the first case it is due to the excess of peroxide, which takes more room than the lead, causing undue expansion in the buttons. In the second case it is caused by a deposit of sulphate on or in the buttons, clogging them so they cannot expand normally. At the first sign of buckling the cause should be determined by the indications given above and the condition remedied.

Impurities in Electrolyte

This condition is usually indicated by the positive plates becoming very light in color and the buttons or active material bulging out of the positive plates and becoming soft, also by change in color of the electrolyte.

Poor Connections

Where the batteries are connected together with bolts, the joints should be watched for heating or corrosion. The first condition may be noticed by taking hold of the joints during overcharge. The second is indicated by a bulge in the tape or paint covering the joint.

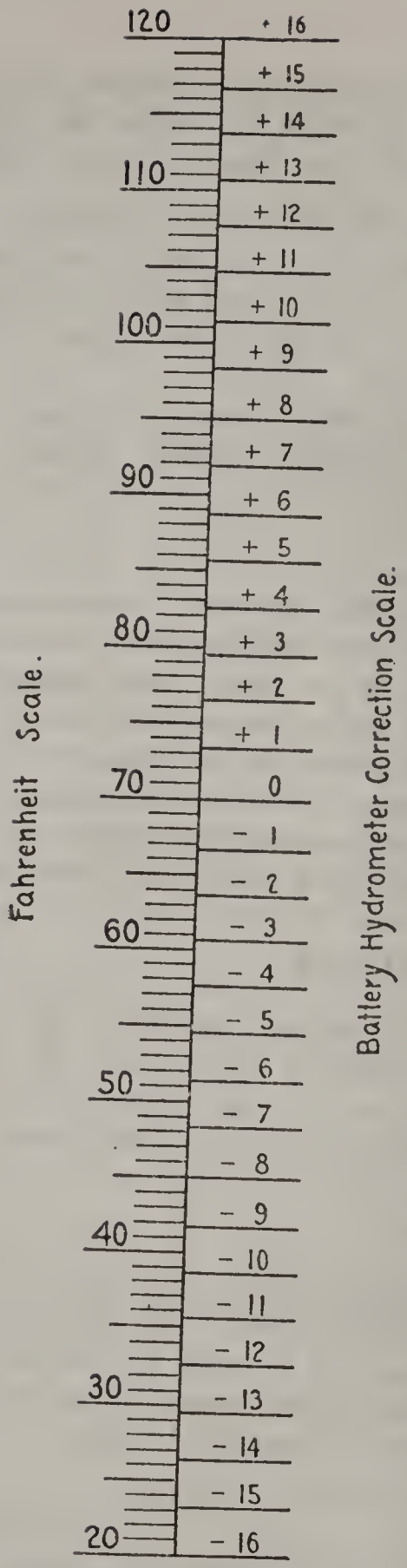

Fig. 23. Thermometer with Hydrometer Correction Scale.

(See page 84)

PRIMARY BATTERIES

DEFINITIONS

Cell

One complete battery unit.

Depolarizer

A chemical compound, which may be either solid or liquid, the object of which is to prevent the hydrogen, which is liberated by the decomposition of the electrolyte, from accumulating on the positive pole.

Electrolyte

The exciting solution in which one or both of the elements are placed.

Elements

Those parts which when immersed in a suitable solution produce an electric current by chemical action.

Jar

A receptacle for holding the electrolyte and the elements.

Porous Cup

A cylinder of porous earthenware closed at the bottom which is used to keep the electrolyte from mixing with the solution in which the zinc is immersed and yet permit an electric current to flow from one to the other.

CHEMICAL ACTION

In all primary batteries, current is produced by the electrolyte attacking the zinc when the circuit is closed, forming a salt of that metal and liberating hydrogen. This hydrogen

tends to collect in minute bubbles on the positive pole and increases the internal resistance of the cell. The depolarizer is usually composed of some substance rich in oxygen which, when the cell is in action, combines with the liberated hydrogen and forms water. In all primary batteries the carbon or copper is the positive pole and the zinc the negative pole.

DESCRIPTION

Primary batteries used in central offices are made up of three types of cells, namely:

STANDARD BATTERIES (FULLER TYPE).
CAUSTIC SODA BATTERIES (LALANDE TYPE).
DRY BATTERIES.

STANDARD BATTERY

Each cell consists of:

1. A glass jar 6″ x 8″.
2. A porous cup.
3. A carbon element.
4. A zinc element.
5. The electrolyte (termed Standard Battery Solution), which also acts as a depolarizer.
6. A solution of common salt.
7. A cover, made of impregnated wood to cover the jar and also to act as a support for the carbon element.

To Set Up Cell

1. Thoroughly coat the zinc and its connecting wire with mercury, first dipping it into the electrolyte for a few seconds.
2. Place zinc in porous cup with the wire projecting above the top of cup.
3. Place one teaspoonful of mercury in porous cup.
4. Place porous cup and zinc in glass jar.
5. Fill porous cup two-thirds full of clean water.

6. Add one tablespoonful of common salt to water in porous cup, dissolving it thoroughly by moving the zinc up and down.
7. Fill glass jar with electrolyte to about $\frac{1}{2}$" below the level of solution in porous cup.
8. Place cover on jar, passing the wire attached to the zinc through the small hole.
9. Insert carbon in slot in cover.

When newly set up, this battery has a potential of about 2.14 volts and the electrolyte has a red color. When exhausted the voltage falls off rapidly and the electrolyte has a green color.

To Renew Cell

Empty the old electrolyte and salt solution, being careful to save the mercury in porous cup as it may be reused indefinitely. Wash all parts thoroughly and proceed as when setting up cell, using new zinc when necessary. After using a porous cup for three or four renewals it may be found that the life of the cell is appreciably shortened. This is due to the formation of crystals in the pores of the earthenware which increases the internal resistance of the cell. These crystals may be dissolved by immersing the porous cup in clean water for from seven to ten days, changing the water daily. If crystals form on the carbon they may be removed in the same manner.

CAUSTIC SODA BATTERY

Each cell consists of:

1. A jar of enamelled steel or porcelain, or heat resisting glass.
2. A copper oxide element which also acts as a depolarizer.
3. A frame or holder for copper oxide element.
4. Two zinc elements.
5. An electrolyte of caustic soda solution.
6. A layer of heavy paraffine oil to prevent the chemical action of the atmosphere on the electrolyte.
7. A cover which also acts as a support for the elements.

To Set Up Cell

1. Fill jar with water such as has been approved for storage batteries (avoid water containing iron, lime, etc.) to within 1¾" of top, disregarding all marks or ridges on the jar.
2. Add gradually one proper sized charge of caustic soda, stirring constantly with a stick of wood until thoroughly dissolved. Be careful not to slop or splash any of the solution on the skin or clothing. If it is splashed accidentally, the part should be washed IMMEDIATELY, and no harm will result.

   Soda must be added slowly and thoroughly dissolved, otherwise it will solidify in bottom of jar. Allow solution to cool to at least 90° F. before immersing elements.

   NOTE: **Never under any circumstances put the soda into the jar first and then the water, as this procedure is dangerous.**
3. See that rubber tubing insulators are in place on the copper frame. Fasten copper oxide plate into position.
4. Pass each zinc stem (lettered side out) through the square holes in cover, and pass brass bolt through the holes in stem and hole in ridge on cover, fastening same in place with wing and jamb nuts. An additional wing nut is furnished for connecting the conductor.
5. When properly assembled, the copper oxide plate is suspended in the centre of cover with a zinc plate on either side. Zincs should hang approximately parallel to copper oxide plate and about ½" distant from it.
5. Immerse elements in electrolyte, noting particularly that the rubber insulators on copper frame are partly immersed in electrolyte, as otherwise the floating particles of copper oxide, which are freed when plates are immersed, will short circuit the cell.
7. Pour the oil on top of electrolyte by moving cover to one side, being careful not to allow any of it to

come in contact with the elements as an insulating film may form on new plates which would reduce the capacity of the cell.

To Renew Cell

The elements and electrolyte are so proportioned that all become exhausted at approximately the same time. When exhausted, the zincs are worn very thin, the copper oxide plate is reduced to metallic copper, and the electrolyte is changed from a solution of caustic soda to a solution of sodium zincate, and it will be necessary to renew the elements and electrolyte.

1. Remove covers with elements attached, empty jar of old electrolyte and wash jar, cover and element support thoroughly, being careful not to allow the solution to come in contact with the skin or clothing.
2. Remove old plates from cover and clean channels of copper frame with sandpaper or emery.
3. Make new electrolyte, fasten new elements to cover, immerse in electrolyte and apply the oil as directed under instructions "To Set Up Cell".

New Type Cell

The above instructions refer to the older types of caustic soda cells. A newer type has been developed in which the elements are assembled complete at the factory. When necessary to renew the newer type cell, the old elements are removed as a unit by unscrewing the clamping nuts on cover and a new complete element placed in its stead. Otherwise the same instructions will apply.

DRY BATTERY

Each cell consists of:

1. A jar or container of zinc which also serves as the negative pole.
2. A carbon element.

3. A powdery depolarizer consisting of manganese peroxide, or its equivalent, which surrounds the carbon element.
4. An absorbent lining which, with the depolarizer, is saturated with electrolyte.

Renewals

Dry cells are so constructed that the depolarizer is depleted and the zinc container used up at about the same time. When the cell is exhausted it is discarded in its entirety and a new cell substituted.

USES

In Central Offices, primary batteries are used to supply current for the following purposes:

STANDARD BATTERY

Voltmeter testing combination with low resistance shunt.

CAUSTIC SODA BATTERY

Operating the vibrating arm on pole changers in local battery central offices.

DRY BATTERY

1. Operating coin collectors.
2. Ringing with pole changers.
3. Silent period.
4. Superimposed ringing.
5. Testing circuits.
6. Circuit trunk booster batteries, etc.
7. Operators' transmitters in local battery central offices.
8. P.B.X. emergency batteries.
9. Operating bells and other signals in local battery central offices, or where it would not be advisable to use central office storage battery for this class of service.

TESTS

STANDARD BATTERY

As this battery is used for testing, its condition should be noted when making regular tests.

CAUSTIC SODA BATTERY

This battery is designed so that the copper oxide plate and electrolyte become depleted at the same time that the zincs are consumed and, as the voltage remains unchanged as long as any copper oxide remains, no test is necessary, but periodic inspections should be made towards the end of the life of the battery by lifting the elements and observing the condition of the zinc.

DRY BATTERY

Coin Collector Battery

This consists of four sets of cells, each set comprising eighty cells with a maximum of 120 volts open circuit. Batteries shall be tested each morning in order to detect defective cells.

Test shall be made by bridging a voltmeter shunted by a 500-ohm resistance across each set. If voltmeter reading shows 110 volts or over at the end of 10 seconds, the set under test shall be considered good. If voltmeter reading shows less than 110 volts each cell shall be tested individually as described under "Individual Cell Tests" and defective cells replaced.

In addition to the daily test a weekly test shall be made of each cell as described under "Individual Cell Tests" and all defective cells replaced.

Main Ringing Battery

This is comprised of from 66 to 80 cells with an open circuit maximum of 100 volts. Batteries shall be tested each week in order to detect defective cells.

Test shall be made by bridging a voltmeter shunted by a 500-ohm resistance across the set. If voltmeter reading shows 80 volts or over at the end of 10 seconds, the set under test shall be considered good. If voltmeter reading shows less than 80 volts, the cells shall be tested individually as described under "Individual Cell Tests" and defective cells replaced. If the individual cells test good a sufficient number of new cells shall be added to bring the open circuit voltage up to 100.

Superimposed Ringing Battery

This is used in connection with pole changers or hand generators and consists of two sets, one for positive and one for negative superimposing. Each set comprises from 42 to 50 cells with a maximum of 65 volts open circuit. Batteries shall be tested each week in order to detect defective cells. Test shall be made by bridging a voltmeter shunted by a 500-ohm resistance across the set. If voltmeter reading shows 55 volts or over at the end of 10 seconds, the set under test shall be considered good. If voltmeter reading shows less than 55 volts, the cells shall be tested individually as described under "Individual Cell Tests" and defective cells replaced. If the individual cells test good a sufficient number of new cells shall be added to bring the open circuit voltage up to 65. The emergency superimposed battery shall be cut into service when tests or replacements are being made.

Superimposed Bell Adjusting Battery

This is used in connection with Wire Chief's low voltage ringing test and consists of two sets, one for negative and one for positive superimposing. Cells shall be tested weekly as described under "Individual Cell Tests" and defective cells replaced. The number of cells varies for different offices, and is shown on the bell adjusting circuit drawing.

Voltmeter Testing Battery

The number of cells varies for different offices and is shown on the testing circuit drawings. Test shall be made

daily by short circuiting a test plug. If set shows one volt or more below the standard, the voltage shall be corrected by adding a new cell or replacing defective cells.

Booster Batteries

These are used in connection with incoming trunks, silent period, etc., to increase the working voltage. The cells vary in number with the increase in voltage desired. Tests shall be made weekly as described under "Individual Cell Tests" and defective cells replaced.

Operators' Transmitter Battery

This is used in local battery exchanges for operators telephone sets. Battery shall be tested each week as described under "Individual Cell Tests" and defective cells replaced.

P.B.X. Emergency Battery

This consists of sixteen cells. Battery shall be tested each week in order to detect defective cells. Test shall be made by bridging a voltmeter shunted by a 100-ohm resistance across the set. If voltmeter reading shows 20 volts or more at the end of 10 seconds, the set shall be considered good. If voltmeter reading shows less than 20 volts, each cell shall be tested individually as described under "Individual Cell Tests" and defective cells replaced.

Batteries for Miscellaneous Purposes

When maintained by the Plant Department, cells shall be tested each week individually as described under "Individual Cell Tests" and defective cells replaced.

Individual Cell Tests

A. Standard Battery Gauge W. E. Co. #35.

With Stem Depressed

If the reading remains at or above the second red mark for a period of one minute, the cell under test shall be considered good for

P.B.X. Emergency and Talking Batteries.

If the reading remains at or above the black mark for a period of 5 seconds, the cell under test shall be considered good for all other batteries than the above.

If the reading is below the black mark, the cell shall be discarded.

B. Eldridge Gauge.

If the reading is at or above the higher calibration mark after 10 seconds, the cell under test shall be considered good for

1. Coin Collector Battery.
2. P.B.X. Emergency and Talking Batteries.

If the reading is at or above the lower calibration mark after 10 seconds, the cell under test shall be considered good for all other batteries than the above.

If the reading is below the lower calibration mark, the cell shall be discarded.

Reserve Batteries

When batteries for similar services are furnished in duplicate, the central office load shall be transferred three times daily—at 10 A.M., 2 P.M. and 5 P.M. Additional transfers shall be made at night if conditions require.

POLE CHANGERS

No. 84 Type Interrupter

DEFINITIONS

Magnet Springs

A pair of contact springs mounted on the vibrator arm support, and connected in the circuit of the operating magnet and battery. The motion of the vibrator arm serves to alternately open and close the contact and thus maintain the arm in motion.

Operating Battery

A battery for operating the vibrator arm.

Operating Battery Reversing Key

A key connected in the circuit of the operating battery to reverse the polarity of the battery at the magnet spring contacts. This reverses the deposit of metal from one contact to the other, which takes place in the direction of current flow.

Operating Key

A small key mounted in the base of the pole changer and connected in the circuit of the operating and ringing batteries. This key is used for starting and stopping the pole changer when a separate key or switch is not provided.

Operating Magnet

An electro magnet connected to the operating battery to keep the vibrator arm in motion.

Pole Changer

An electrically operated vibrating device, by means of which the direct current furnished by a battery may be rapidly reversed in direction, or interrupted, to produce an alternating or pulsating current.

Ringing Battery

A battery of dry cells connected to the ringing springs to furnish alternating and pulsating ringing current.

Ringing Springs

Four pairs of stationary contact springs connected to the ringing battery and to the positive pulsating and negative pulsating binding posts. When the vibrator arm is in motion, the contacts of the ringing springs engage the contact points mounted on the swinging end of the arm.

Vibrator Arm

A swinging arm suspended between pivots and arranged to be kept in motion by an electro-magnet. The swinging end of the arm is equipped with contact points, which alternately make contact with the positive and negative ringing springs.

Vibrator Arm Set-Nuts

A pair of knurled thumb-nuts located on the swinging end of the vibrator arm and used for adjusting its speed.

Vibrator Arm Spring

A spiral spring attached to and used for adjusting the speed of the vibrator arm and the ringing current voltages.

DESCRIPTION

Four styles of the #84-type interrupter are in use. These differ only in the winding of the operating magnet and are as follows:—

Type of Interrupter	No. of Operating Cells	Voltage	Type of Operating Battery
84-A	11	20-28	Storage
84-B	2	1.4 (Approx.)	Lalande
84-C	17	31-43	Storage
84-E	1	.7 (Approx.)	Lalande

All styles of the #84-type interrupter are wired in the same manner.

In common battery offices a #5-AA retardation coil is connected in the ringing ground lead to prevent noise on the battery.

OPERATION

The key used for starting the pole changer may be the operating key provided in the base of the instrument, a switch located on the power switchboard, or a key installed on the face of the switchboard.

When a separate operating key or switch is provided, the operating key in the base of the pole changer should always be left in its "ON" position, except when adjusting or testing the instrument.

To Start

Close the operating key or switch.

NOTE: If pole changer does not start promptly restore the operating key or switch and inspect for trouble as described later. Do not attempt to start the pole changer by jarring or by swinging the vibrator arm with the hand.

To Stop

Restore the operating key or open the switch.

To Transfer Load from one Pole Changer to Another:

1. Start pole changer to be cut into service.
2. Throw transfer switches.
3. Test ringing.
4. Stop pole changer to be cut out of service.

RESERVE SETS

When emergency superimposed current batteries are provided for use with either pole changer, they shall be used one day each week.

Where two pole changers are provided, they shall be operated on alternate days.

Where three pole changers are provided, they shall be operated regularly as follows:

	First Half of Switchboard	Second Half of Switchboard		Entire Switchboard
1st Day	P.C. #1	P.C. #2	1st Night	P.C. #2
2nd Day	P.C. #2	P.C. #3	2nd Night	P.C. #3
3rd Day	P.C. #3	P.C. #1	3rd Night	P.C. #1
4th Day	Same as 1st day, etc.			

Where the exchange load is not great enough to require the use of two pole changers during the day, each pole changer shall be operated on the entire switchboard every third day.

TROUBLES

Stopping or Failure to Start may be due to:

1. Low voltage of primary operating battery.
2. Open operating battery circuit.

3. Poor contacts on magnet springs.
4. Improper adjustment of magnet springs.
5. Improper adjustment of spiral spring.
6. Location of vibrator, arm too near operating magnet.
7. Worn or loose pivot screws.

Sparking at Contacts may be due to:

1. Rough contact points.
2. Contact springs out of adjustment.
3. Open condenser circuit.
4. Open non-inductive resistance circuit.
5. Ground on ringing leads.

Noisy Operation may be due to:

1. Vibrator arm striking operating magnet.
2. Worn or loose pivot screws.

Loss of Ringing Current may be due to:

1. Open battery fuses.
2. Open connections of dry cells.
3. Defective dry cells.
4. Grounded ringing leads.
5. Springs out of adjustment.
6. Short or open circuit in pole changer.

CARE AND MAINTENANCE

Adjustment of Ringing Springs

The vibrator arm and operating magnet are so placed that the ringing springs have a considerable margin of adjustment. The ringing springs should not be readjusted unless a careful inspection has first shown them to be out of adjustment. Remove the ringing battery fuses before adjusting the springs.

When the vibrator arm is held in the middle of its swing, the distance between the contacts on the arm and the inner ringing springs (see page 112) should not be less than .01 inch or more than .015 inch. If the distance is less than .01 inch on a side, there is a possibility of a short circuit between the

two springs. If the distance is greater than .015 inch, the ringing voltage will be low. With proper adjustment the voltage of the alternating current should be about 80 per cent. of the voltage of the ringing battery.

The distance between the contacts of the outer and inner ringing springs, "A" and "C" and "A" and "F" (see page 112), may be less than the distance between the contacts of the vibrator arm and inner springs, since both springs are of the same polarity. In most cases, a break distance .01 inch will be found satisfactory. If this distance is exceeded the pulsating voltage will be low.

The above distances should be measured by means of the gauges accompanying each instrument.

In making adjustments as above, it should be borne in mind that when swinging in either direction, the alternating and ground contacts of the vibrator arm should make contact at the same instant with their ringing springs; also that when the vibrator arm forces the inner springs against the outer springs, the contacts of the two sets of springs must make at the same instant.

The springs should have a slight tension in the direction of their stop springs and lie flat against them for their entire length. In case it becomes necessary to adjust the ringing springs, their stop springs should, if necessary, be adjusted also, to keep the same relative position; that is, the ringing springs should remain lying flat against their stop springs, as described above. If, in order to properly adjust the ringing springs, considerable movement of these springs is necessary, the entire group of springs should be moved by loosening the screws which fasten these springs to the post, after which a complete readjustment and spacing of the springs of the interrupter will be necessary.

When the vibrator arm is in motion, the ringing springs "A" should not strike the stop springs of the outside ringing springs "C" and "F." (See page 112)

Adjustment of Magnet Springs

The inner magnet spring "D" (see page 112) should have sufficient tension on the bumper pin to cause it to follow the

vibrator arm through its entire stroke. The outer magnet spring "E" (see page 112) should have sufficient tension in the direction of its adjusting screw "S" (see page 112) to cause it to lie flat against its stop spring and also sufficient tension in the direction of the inner magnet spring to cause it to follow the latter nearly to the point where the alternating and ground contact points make contact with the ringing springs. Care should be observed in making this adjustment to insure the opening of the contact at the proper time in order not to consume an undue amount of power, and yet provide a strong enough swing.

The bumper pin underneath the inner magnet spring is made of hard rubber and very carefully polished. After being in service for some time this pin is liable to become roughened. It should be polished occasionally with crocus cloth, as the wear is very materially increased if allowed to go on after it has become roughened.

Adjustment of Vibrator Arm Spring

The best regulation of the vibrator arm when the operating voltage varies is obtained when the tension in the spiral spring is light. Care should therefore be taken to avoid increasing the tension more than is necessary. The tension should be sufficient to close the magnet spring contacts when the vibrator arm is at rest, insure the proper positive pulsating voltage and prevent the vibrator arm locking over against the operating magnet when the starting switch is closed.

Care of Contacts

If contacts become rough, they shall be polished with crocus cloth.

Speed Regulation

The rate of vibration of the vibrator arm should be about 1,000 per minute.

The vibrator arm speed may be increased by moving the vibrator arm set-nuts nearer the operating magnet and decreased by moving them further away from the magnet. The

proper location of these nuts, when the other adjustments are properly made, is in the center of the threaded portion of the vibrator arm.

The speed of the vibrator arm is also affected by the tension of the spiral spring and the adjustment of the magnet spring contacts.

It is important that the tension of the spiral spring be not too heavy, nor the vibrator arm too near the operating magnet.

The interrupter speed can be satisfactorily adjusted by the use of a set of biased test bells. When two interrupters are provided, their speeds may be compared and adjusted by ringing the test bells alternately from either interrupter. When but one interrupter is provided, its speed may be adjusted by ringing the test bells first with the hand generator and then with the interrupter.

Voltage Regulation

With the ringing springs and vibrator arm properly adjusted, the comparative voltages at the binding posts of the pole changer should be as follows:

Voltage of Ringing Battery	Alternating Voltage	Pulsating Voltage (with A.C. Voltmeter)	Pulsating Voltage (with D.C. Voltmeter)
80	67	49	32
85	71	52	34
90	75	55	36
95	79	58	38
100	83	61	40

Increasing the tension of the spiral spring raises the positive pulsating voltage, while tightening the screw of the outer magnet spring "S" (see page 112) raises the negative pulsating voltage. The alternating voltage also is affected by these adjustments, being raised when the adjustments of the spiral spring and magnet spring contact increases the swing of the vibrator arm, and lowered when their adjustment decreases the swing.

When regulating the voltage, readings should in all cases be taken of the positive and negative pulsating voltages and

these voltages made to correspond. In offices where pulsating ringing current is not used, this is necessary in order to insure an alternating current made up of equal positive and negative impulses.

No attempt shall be made to increase the ringing voltages by adjusting the pole changer without first measuring the voltage of the ringing battery, as provided in Section on "Primary Batteries", to determine that its voltage is within the limits shown on the ringing circuit drawing for the particular office.

Battery Maintenance

The operating, ringing, and superimposed current batteries used with pole changers shall be maintained in accordance with the instructions in section on "Primary Batteries".

Inspections

In offices covered regularly by a plant man, the pole changers shall be inspected weekly for the following:

1. Failure to start promptly when operating key is closed.
2. Sparking at contacts of ringing or magnet springs.
3. Noisy operation.
4. Tendency of vibrator arm to stick against magnets.
5. Speed of vibrator arm.
6. Voltage at operating battery binding posts (when primary battery is used).
7. Voltages at alternating and pulsating current binding posts.
8. Condition of contacts.

In offices not regularly covered by a plant man, inspections shall be made weekly if possible. When this is not practicable, inspections shall be made whenever a plant man visits the office.

Reversing Key

The operating battery shall be reversed weekly by means of the reversing key.

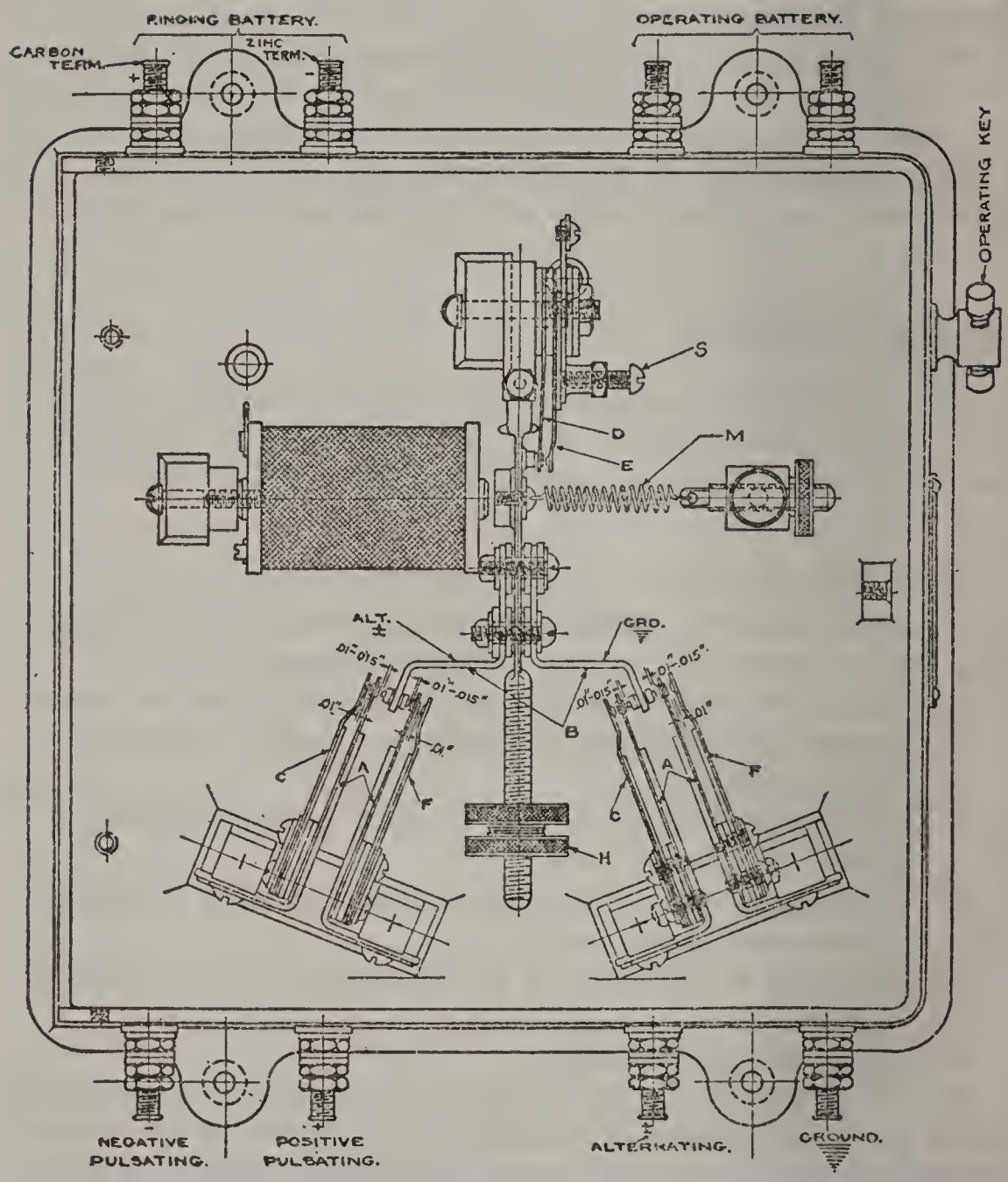

Fig. 24. #84 Type Interrupter.
(See pages 107, 108, 109 and 110)

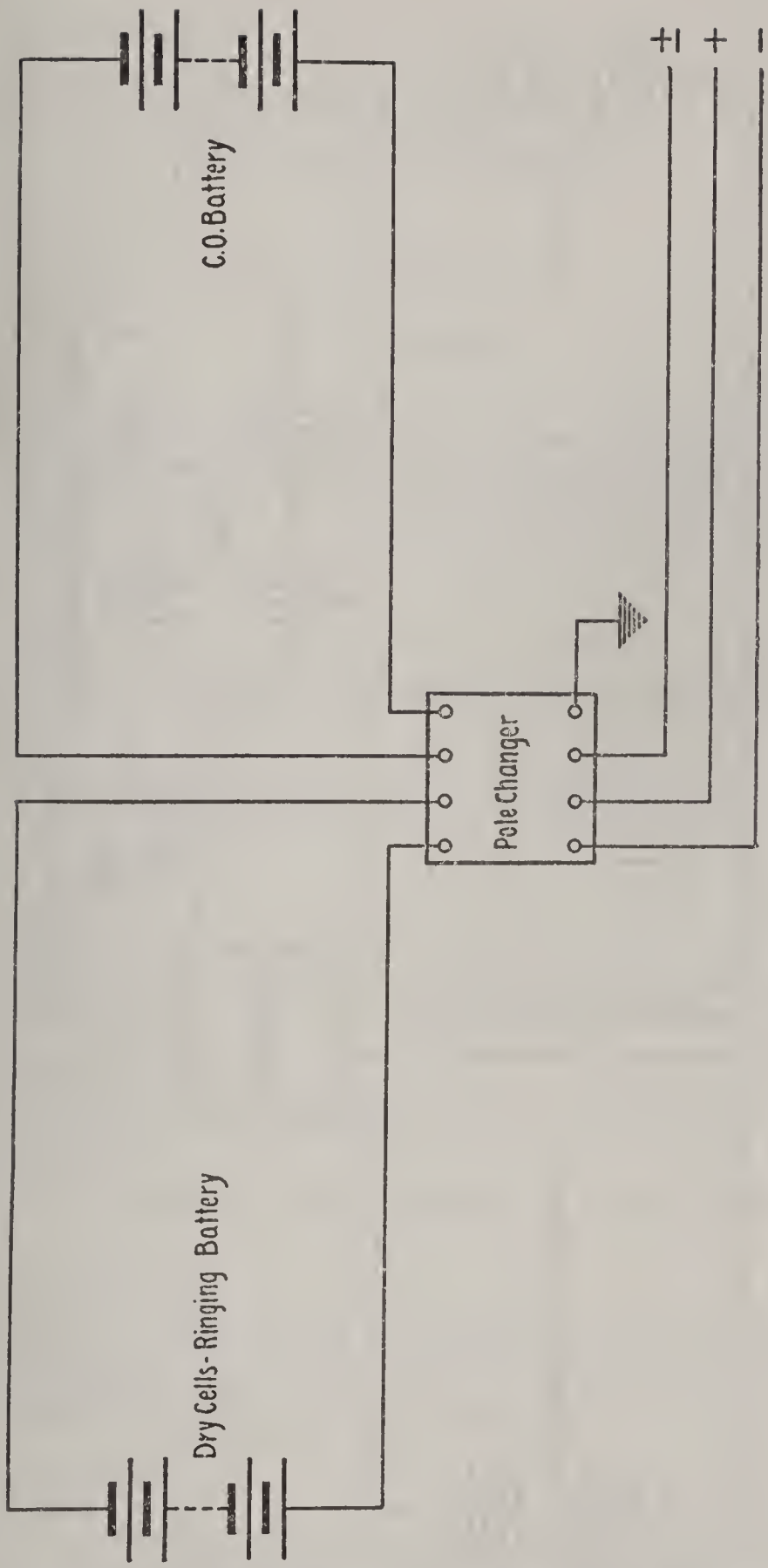

Fig. 25. Pole Changer—Pulsating Ringing

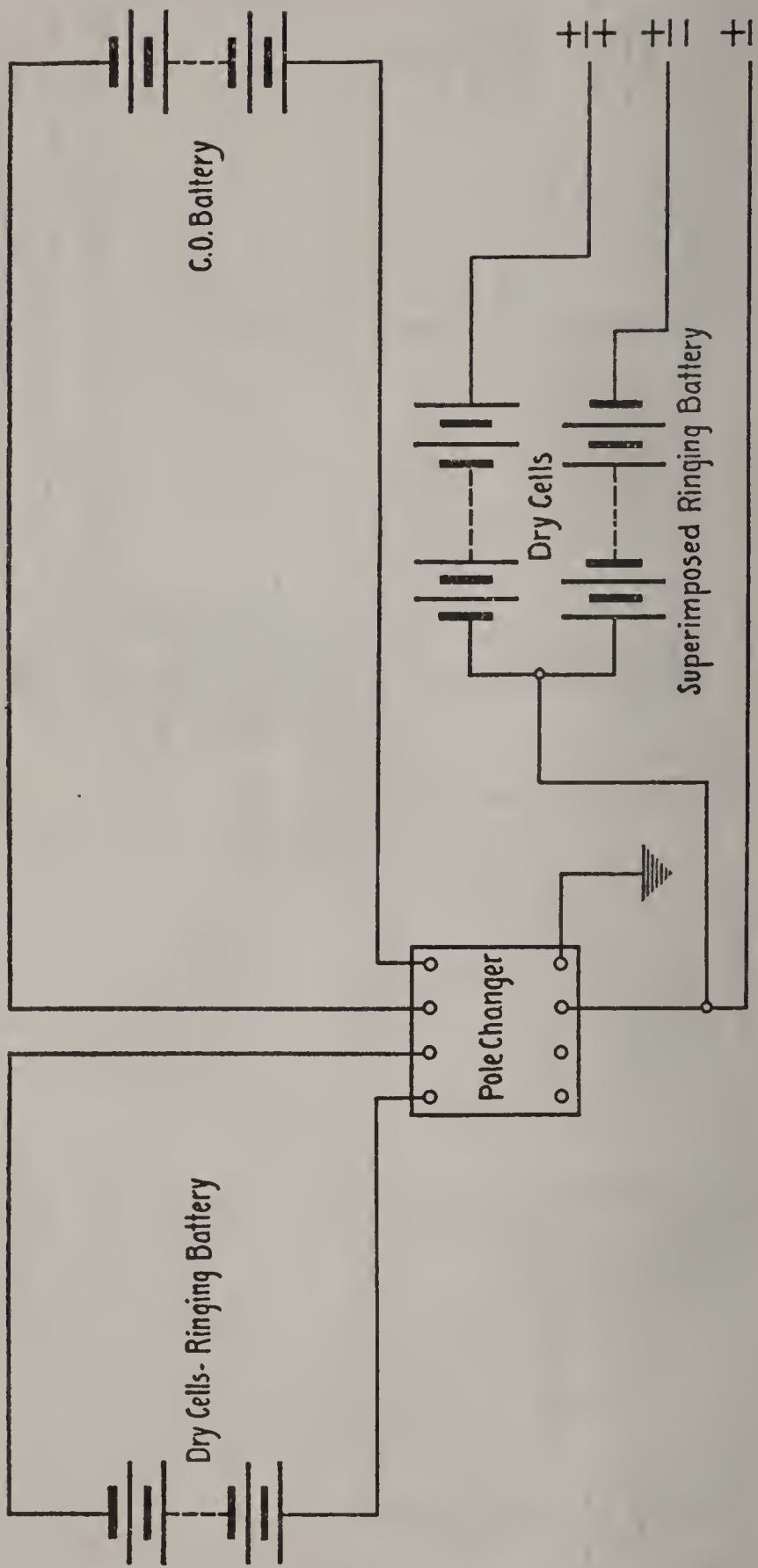

Fig. 26. Pole Changer—Superimposed Ringing.

MISCELLANEOUS POWER AND LIGHTING APPARATUS

FUSES

DEFINITIONS

Fuse

A protective device consisting of two terminals between which is connected a section of alloy which melts when the current flow exceeds a predetermined amount and thus opens the circuit.

Fuse Wire

A wire made of alloy which melts at a predetermined temperature.

NOTE: Fuse wire shall not be used without Wire Chief's permission, except as noted under "Power Fuses".

Link Fuse

A fuse having the alloy exposed and soldered to terminals.

Mica Fuse, #24-Type

A fuse having the terminals and alloy supported on a strip of mica.

NOTE: Mica fuses are made only in small capacities.

Mica Fuse, #35-Type

A mica fuse equipped with a mechanically indicating device and so arranged that when the fuse operates, audible and visible signals are automatically given.

Non-Arcing Fuse

A fuse having the alloy enclosed in a fibre sleeve provided with a device to indicate when the fuse has operated.

CARE AND MAINTENANCE

General

Any employee who is directly responsible for placing in service fuses of unauthorized capacity, or any employe who detects unauthorized fuses in service and who fails to notify Wire Chief or Foreman, or any employe whose duty it is to inspect this apparatus and who fails to make such inspections or to detect the existence of unauthorized fuses, shall be liable to dismissal.

Special attention shall be given to the inspection of fuses while outside forces are working in the building.

A sufficient number of spare fuses of the various types and sizes used in the central office, and a spool of 1-ampere fuse wire shall be kept on hand at all times.

In buildings where no licensed engineer is stationed, a stock of electric light and power service fuses shall also be carried by the Wire Chief.

Fuse drawers with compartments marked to indicate the type and capacity of fuses contained therein shall be provided and mounted at convenient points in the terminal room.

Tools for replacing fuses shall be kept near the power board, and an inspection shall be made at 8:00 A.M. and 5:00 P.M. to insure their being in proper place. The ampere capacity of the proper link or non-arcing fuse to be used shall be marked in each case near the fuse studs.

When fuses are placed in service, the contact surfaces of fuse terminals and fuse studs shall be thoroughly cleaned. Screws holding fuses in place shall be tightened with a wrench or screw-driver, but care shall be exercised to prevent damaging the heads of screws, twisting lugs or injuring fuses. Where two or more fuses are placed in multiple, special care shall be taken to keep the contact resistances at a minimum, so that each fuse will carry its share of current. Uneven distribution of current reduces the total capacity of fuses in multiple.

Power fuses shall be inspected weekly for proper capacity, excessive heating and general condition.

Battery Discharge Fuses

In case a fuse equipped with a short circuiting device should operate, the short circuiting device shall be closed before attempting to replace the fuse. After the new fuse has been placed, it shall be ascertained by observation of the discharge ammeter that the load is below the carrying capacity of fuse before the short circuiting device is opened. In case a fuse not so equipped should operate, the circuit shall first be closed with a heavy screw-driver or other suitable piece of metal. The metal shall be held firmly against the fuse studs to avoid opening the circuit after it has been established, as the resulting arc would quickly heat or burn the metal.

Mica Fuses

When a main fuse operates, it generally happens that when the circuit is restored, a large number of mica fuses also operate, due to the excessive load. When this condition occurs, the retaining screws shall be loosened and 1-ampere fuse wire shall be temporarily wound, in zig-zag fashion, between the retaining screws on the bus bar and those on the fuse studs, in order to restore service as quickly as possible; after which the old mica fuses shall be individually replaced with new mica fuses and the fuse wire shall be removed.

When replacing mica fuses, the retaining screws shall be loosened sufficiently to allow the fuse to be slipped into place without force. If necessary, the screw shall be entirely removed from the bus bar or stud. Care shall be exercised to avoid damaging the fuse. Fuses shall be placed with the fuse wire toward the outside.

In replacing mica fuses of the #35-type, inspect the flat feather spring on the underside of fuse and see that the end is midway between the two rivets which fasten the metal terminal to the mica base. If the spring is found to be bent, the fuse should be discarded. Fuses shall be inserted so that the terminal carrying the feather spring shall be connected to the bus bar. After the fuse is secured in place, inspect fuse by sighting through the fuse wire hole in the mica base. If the alarm spring is not properly centered, the fuse shall

be removed. The fuse shall also be inspected to see that the end of the brass wire carrying the indicator bead is not in contact with the metal bus bar terminal.

When, for any reason, a large number of adjacent mica fuses operate, service may be restored temporarily by means of fuse wire as described above. After replacing a mica fuse, make entry in fuse book, showing circuit and fuse number, time and initials of the party making the replacement.

Mica fuses shall be inspected monthly for the following irregularities:

1. Improper type.
2. Unauthorized capacity.
3. Broken micas.
4. Loose connections.
5. Crosses.
6. Wrongly placed fuses.
7. More than one fuse per stud.

All irregularities shall be corrected at once and Wire Chief notified.

Electric Light and Power Fuses

Fuses located in transformer vaults shall be replaced by Light or Power Company employes only. Fuses, other than those located in transformer vaults, may be replaced by the Wire Chief or engineer. Extreme care shall be exercised to prevent accident, either to person or property, while attempting to replace fuses. No fuse shall be replaced until the load has been removed from the circuit.

In case a service fuse should operate, in connection with duplicate service, the duplicate service switch shall be thrown to the other source of supply. After the fuse has been replaced, the switch shall be thrown back to its original position.

The use of 10-ampere link fuses for circuits designed to carry 660-watts is allowable, but it is desirable that link fuses of 6-ampere capacity, or less, be used on such circuits wherever practicable. Wall and ceiling electric light outlets will be fused only at the panel box, in accordance with Underwriters' requirements.

SWITCHES

DEFINITION

Switches are devices used to open or close electric circuits. All switches mounted on the power boards are designated to indicate the circuit which they control.

CARE AND MAINTENANCE

The contact surfaces of switch blades and jaws shall be kept clean and smooth, and the bolts securing the cross-bars and handles shall be kept tight. When insulating fibre stops are provided, they shall be kept in place in the switch jaws at all times when the switches are not closed.

AMMETERS AND VOLTMETERS

CARE AND MAINTENANCE

Under no circumstances shall instrument seals be broken or ammeter shunt leads repaired by the central office force.

Any defects shall be immediately reported to the power plant supervisor.

RESISTANCE LAMPS

DESCRIPTION

Resistance lamps are used as protective devices and are wired in series with the source of current supply, the object being to limit the amount of current flow under the most severe condition. Resistance lamps are placed in all coin collector battery feeders and in the majority of ringing generator feeders.

INSPECTION

The resistance lamps and sockets used in connection with the above circuits shall be inspected quarterly for proper resistance and socket defects. This inspection shall be made during the months of February, May, August and November. Defects discovered shall be remedied at once and a report made to the Wire Chief.

ALARMS

Audible alarms are provided in connection with sources of battery, message register and ringing generator supply, and when operated indicate an abnormal condition or a total failure of supply.

Alarms are divided into two classes, namely:

FUSE ALARMS.
MACHINE ALARMS.

FUSE ALARMS

Audible and visible signals are provided in connection with fuses to indicate when the fuse operates. These alarms are provided in connection with message register feeders, coin collector feeders, private branch exchange feeders, line relay, line lamp and other important central office feeder circuits.

OPERATION

1. Where #24-type fuses are used in connection with message register, private branch exchange, line relay, line lamp and other important central office battery feeders, a #51-type drop is bridged across the fuse terminals. When fuse operates and the circuit is closed, current flows through the winding and energizes the drop. This releases the shutter, which closes a local bell circuit. The bus bar and fuse number are painted on the face of the drop to indicate the fuse that has operated. (See page 128)
2. Where #24-type fuses are used in connection with central office fire drill bell, a #51-type drop is bridged across the fuse terminals. To the outside fuse terminal is connected a 1200-ohm resistance to ground. When fuse operates, battery flows through the drop and resistance to ground, and the drop shutter is released, which closes the local bell circuit. (See page 129)
3. Where #35-type fuses are used in connection with message register, private branch exchange, line relay, line lamp and other important central office

battery feeders, a special bus bar is placed between the fuse studs and battery bus bar. When fuse operates, the feather spring, located on underside of fuse, is released and makes contact with the alarm bus bar, which closes the circuit through a pilot lamp and relay to ground. The operation of this relay closes the alarm bell circuit. The pilot lamp indicates the bus bar and the raised bead indicates the fuse. (See page 130)

4. Where #35-type fuses are used in connection with coin collector battery feeders, the circuit and operation are the same as (3) except that the pilot lamp is omitted.

CARE AND MAINTENANCE

All fuse alarm drops used in connection with #24 fuses shall be tested annually during the month of June in the following manner:

Remove the fuse in the lead that is common to each group of drops. Touch the fuse stud with the end of a wire, the other end of which is connected to ground through a 1⅓ ampere fuse. The ground fuse should operate the instant the ground wire touches the common wire stud. At the same instant all drops in good working condition should operate. Drops that fail to operate shall be tested separately. All drops shall be inspected for shutters that stick and for other defects. The local circuit, bell or buzzer, shall be tested by operating each shutter manually.

In central offices where one fuse is common to more than one group of drops, test shall be made by removing the common wire and applying the ground wire at that point. All strap connections shall be inspected.

MACHINE ALARMS

Message Register Generator Alarm

An alarm is provided in connection with message register generators to indicate a variation of three volts above or below the required e.m.f., which is normal at 39 volts.

OPERATION

This alarm consists of a Weston Electrical Instrument Company's model #30 relay equipped with iridium ball contacts and a #122-CT relay wired in connection with the contacts of the #30 relay. These contacts are so adjusted that if the e.m.f. variation is greater than 6 volts, the #122-CT relay is operated, which in turn operates the alarm bell. (See page 131)

When the alarm operates and the generator is still running, with no indication of contact trouble, adjust the voltage to the proper point by manipulating the generator field rheostat. If the generator has stopped, start the reserve set as provided in section on "Motors and Generators".

Ringing Generator Alarm

An alarm is provided in connection with ringing generators to indicate low voltage.

OPERATION

The alarm consists of a #85-type relay with three 2 M.F. condensers wired in series and bridged across the ringing current bus bars at fuse panel. The apparatus is mounted in the rear of power board.

When generator voltage drops, the relay is released and closes a local contact, which completes the circuit through a direct current vibrating bell operated by storage battery current. A 37-ohm resistance and condenser are bridged across the contacts of the bell to reduce the sparking at that point. The bell rings continuously until the ringing current is restored.

The alarm shall be observed for operation whenever the central office load is transferred from one machine to another. The alarm shall also be tested once a month. This test shall be made by removing the fuse from the lead supplying the ringing current to the #85-type relay and observing the operation of alarm and bells connected to the circuit. (See page 132)

ELECTRIC FANS

Electric fans are provided in operating and terminal rooms in order to improve the ventilation.

CARE AND MAINTENANCE

Fans will be dusted daily by the Real Estate force, otherwise the maintenance devolves upon the Wire Chief's force.

INSPECTION

During the season when operated, electric fans shall be inspected daily (prior to 10:00 A.M. unless otherwise specified) for the following:

1. Oil leaks.
2. Heating or improper operation.
3. Pendant cord not securely fastened by means of sewing twine to lower portion of fan guard.
4. Pendant switch not in danger of making contact with fan guard or being pulled through back of guard by fan blades.

During the entire year fans shall be inspected monthly to see that:

1. Commutators, brushes, blades, guards, and leads are in good condition.
2. Lubricating cups are filled and operate properly.
3. Ceiling fans are secure.
4. Fans operate properly.

ELECTRIC LIGHT AND POWER CIRCUITS

OPERATION

Wiring

Under no circumstances shall any changes be made in wiring on central office premises unless authorized by the Office. All requests for changes in wiring shall be forwarded to the office by the Wire Chief.

Failure of Current Supply

Whenever the light or power current supply fails, the Wire Chief shall immediately take the necessary steps to restore telephone service to normal, notify the Light or Power Company of the failure and report condition to the office.

Duplicate Electric Service Feeds

All members of the force whose duties require them to operate any part of the power plant, shall familiarize themselves with location and operation of switches in connection with this service. Before operating these switches, battery driven sets shall temporarily be placed in service.

In general, where light and power circuits are wired to separate switches, the power switch should be connected to one source of supply and the lighting switch to the other.

Fuses—See Page 118.

Polarity of Hubbell Receptacles

1. In new offices and offices not equipped with Hubbell receptacles, any receptacles which are installed will be of the polarity type. This type is similar to the ordinary Hubbell receptacle except that the contacts are at right angles to each other, thereby insuring the proper insertion of the plug. All polarity type receptacles shall be installed so as to have ground side of the circuit, if any, connected to the horizontal contact of the receptacle. This contact should be uppermost if the receptacle is so placed that one contact is above the other and to the right when the receptacle is placed with the contacts side by side.
2. In buildings which are now partly or wholly equipped with the original type Hubbell receptacle, the use of this type will be continued for any additions or replacements. The polarity of these receptacles and associated plugs shall be indicated as follows:
   (a) **Receptacle.** The face plates used in connection with these receptacles are held in place by two wood screws. Where these screws are

vertical, lower screw shall be provided with an additional slot at right angles to regular slot, thus forming a "+" mark. If screws are in a horizontal position, screw having the extra slot shall be placed to the left.

After the "+" screw is inserted, the slot shall be filled with black lead or some similar substance, in order to facilitate the detection of any change.

(b) **Plug.** One prong of plug shall be stamped with a "+" mark. It shall be noted in "a" and "b" that the "+" mark is used only to designate the live or non-grounded side of circuit and does not necessarily designate positive side of circuit.

Wire Chiefs will be responsible for proper marking of all present and future installations of this apparatus.

In offices using non-grounded lighting circuits, designations such as the above will be unnecessary.

(c) **Lamp Socket.** Extension cords shall be made up so that exposed metal parts of lamp socket shall not be connected to marked prong of plug.

Drop Light Cords

Electric light cords in terminal rooms shall, when replaced, be left extra long in order to avoid unnecessary changing of cords when making repairs. Portable or drop electric light cords which are known to be defective in any way, or the appearance of which suggests improper condition, shall not be used but shall be repaired or their condition immediately reported. If, while using portable electric light cords, it becomes necessary to leave vicinity of work, the cord shall be disconnected from the lighting circuit.

One emergency lamp cord, properly tagged, shall be kept in an accessible place in each operating and terminal room. Metal guards or reflectors shall not be used on drop or

portable light cords in the vicinity of storage batteries, power boards, fuse panels or machines, without special permission. Cords used at the above points shall be equipped with insulated lamp sockets of the keyless type.

ROUTINE INSPECTIONS

Extension Cord Outlets

Shall be inspected and tested weekly by connecting a lamp to each socket. Twin plug outlets or Hubbell receptacles, used on grounded lighting circuits, shall be inspected for polarity. Troubles found shall be remedied and a report made to Wire Chief.

Drop, Portable and Emergency Lamp Cords

Shall be tested weekly for cut-outs and other defects by lighting lamp, shaking cords, and operating socket keys.

Protector handles, cords, lamp sockets, guards and ceiling outlets shall be inspected.

Twin or Hubbell plugs on portable or emergency lamp cords used on grounded lighting circuits shall be inspected for polarity. Troubles found shall be remedied and a report made to Wire Chief.

Electric Light, Power Service and Protection Panels and Distributing Panel Boxes

A monthly inspection shall be made in each central office building of:

1. Street and house panels, except when located in transformer vaults.
2. Distributing panel boxes.
3. Electric light and power switchboards.
4. Power protection panels.

Panel boxes shall be inspected for:

Improper type or unauthorized capacity of fuses.
Improperly placed fuses.
Loose connections.
Reserve supply of fuses and fuse blocks.
Electric lamp, where provided.
General condition.

Fuses and Fuse Blocks

A supply of each type of fuse shall be maintained in good condition at all times by either the Wire Chief or the engineer.

Where removable fuse blocks are used, an extra block equipment with fuses shall be kept in each panel box.

At buildings where there is a licensed engineer, he shall be responsible for replacement of fuses, maintenance of necessary stock, routine inspections and cleaning of equipment. At other buildings, the Wire Chief's force shall be responsible for this work.

Where extensive cleaning is necessary, the work will be done by the janitor under direction of the Wire Chief or his representative.

Switchboard Framework, Electric Light Conduits and Foot Rails

Each month a test of switchboard and local desk framework, foot rails and electric conduits shall be made to determine whether or not they are grounded, or crossed with electric light circuits. Troubles found shall be referred to the Wire Chief. Test shall be made by the use of a test receiver at each section from the front of the switchboard to see that the foot rails are clear of grounds, and that conduits, switchboard and local desk framework are grounded.

Conduit and Floor Plan

All members of the Wire Chief's force responsible for the operation of machines shall familiarize themselves with the location of conduits.

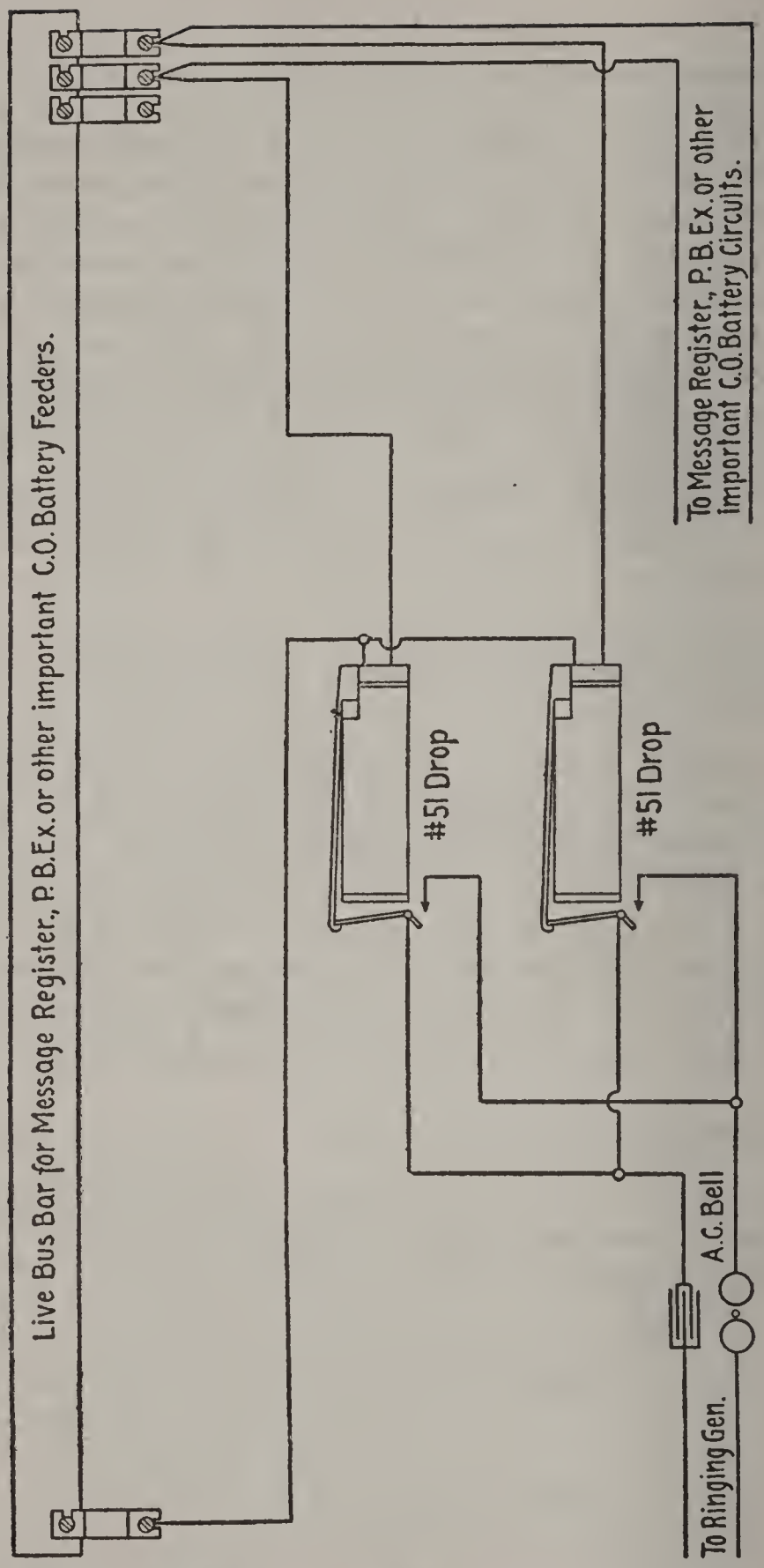

Fig. 27. Fuse Alarm Signal—#24 Type Fuses.
(See page 120)

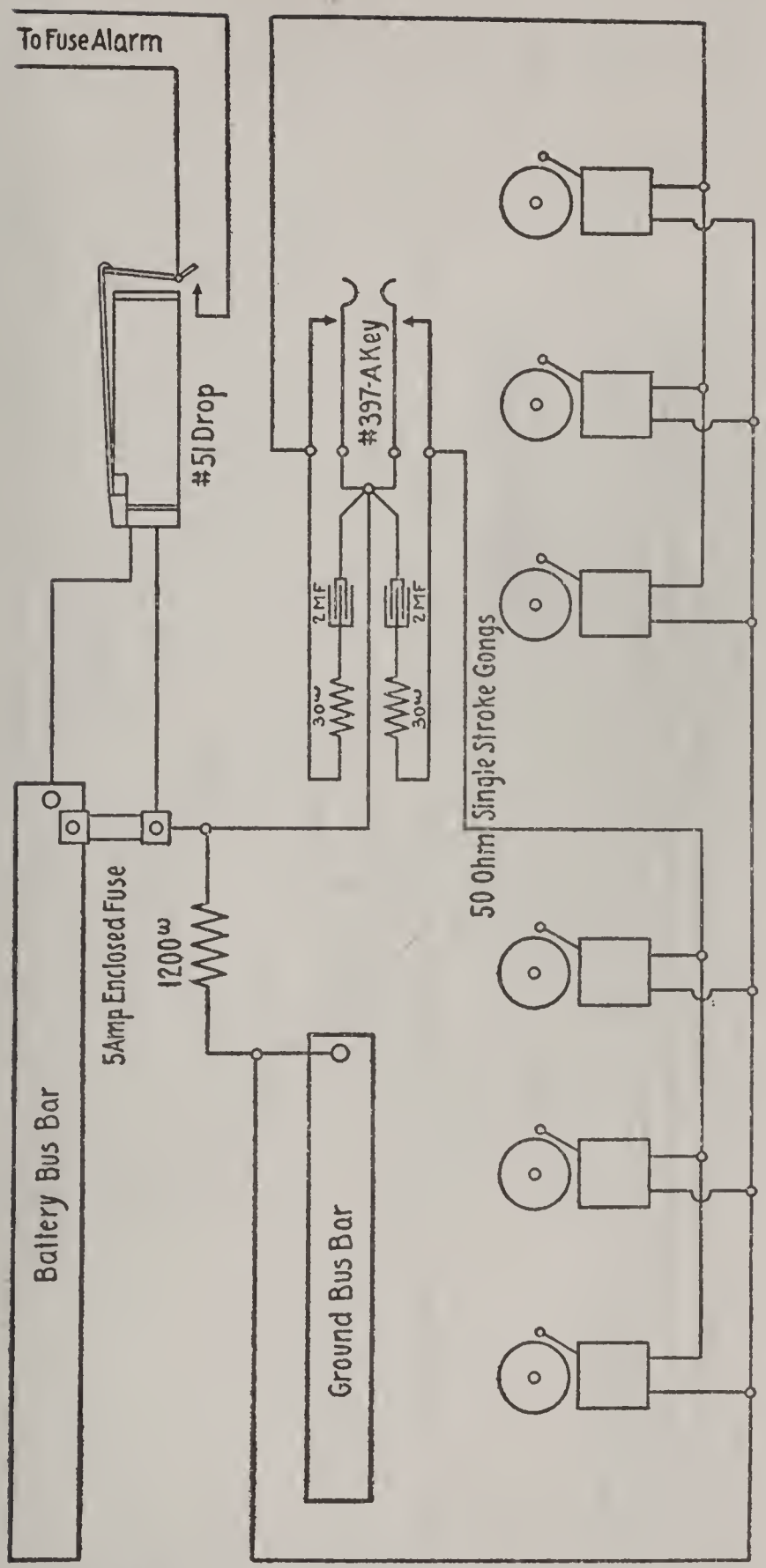

Fig. 28. Fuse Alarm Signal for Central Office Fire Drill Bell—#24 Type Fuses.

(See page 120)

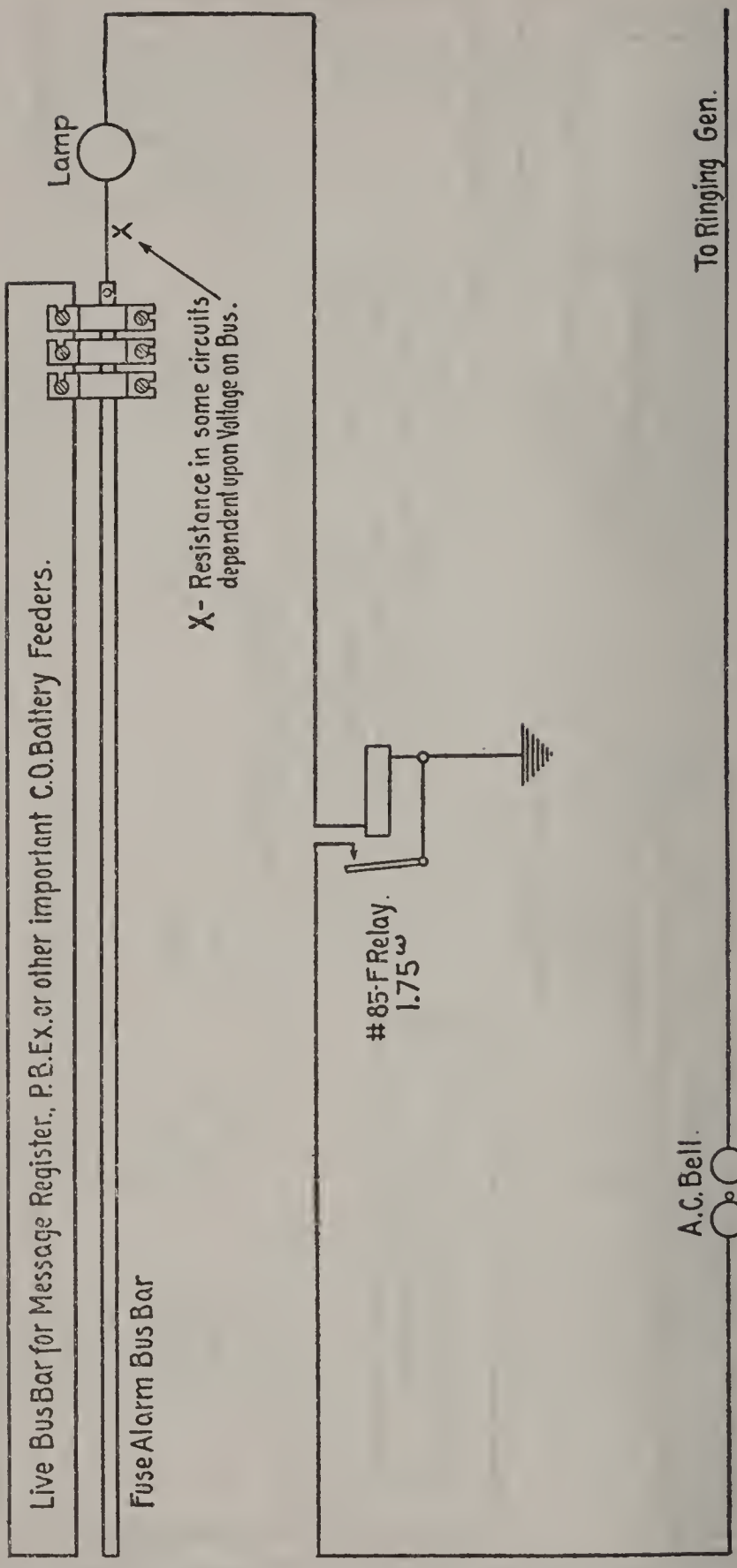

Fig. 29. Fuse Alarm Signal—#35 Type Fuses.
(See page 121)

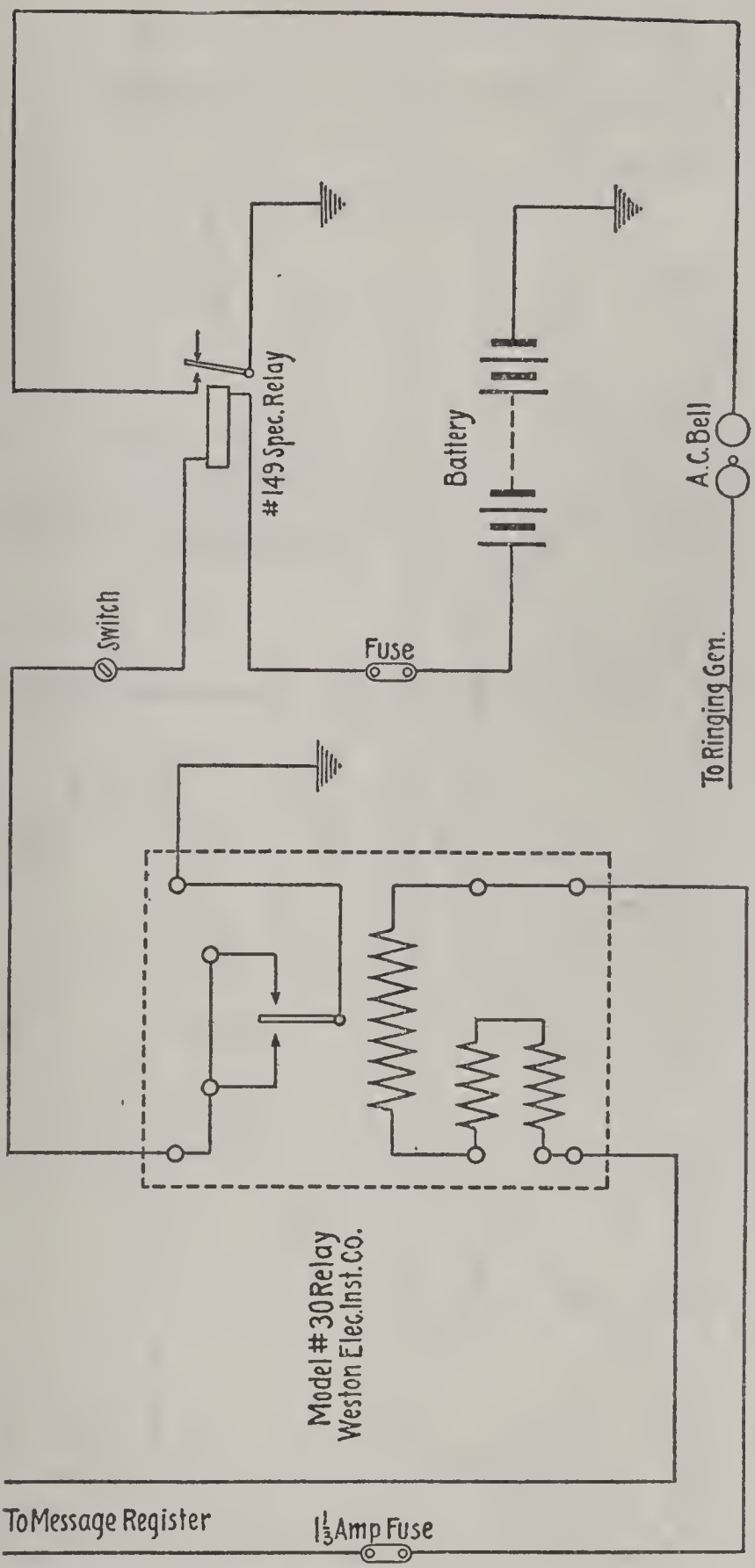

Fig. 30. Message Register High and Low Voltage Alarm.
(See page 122)

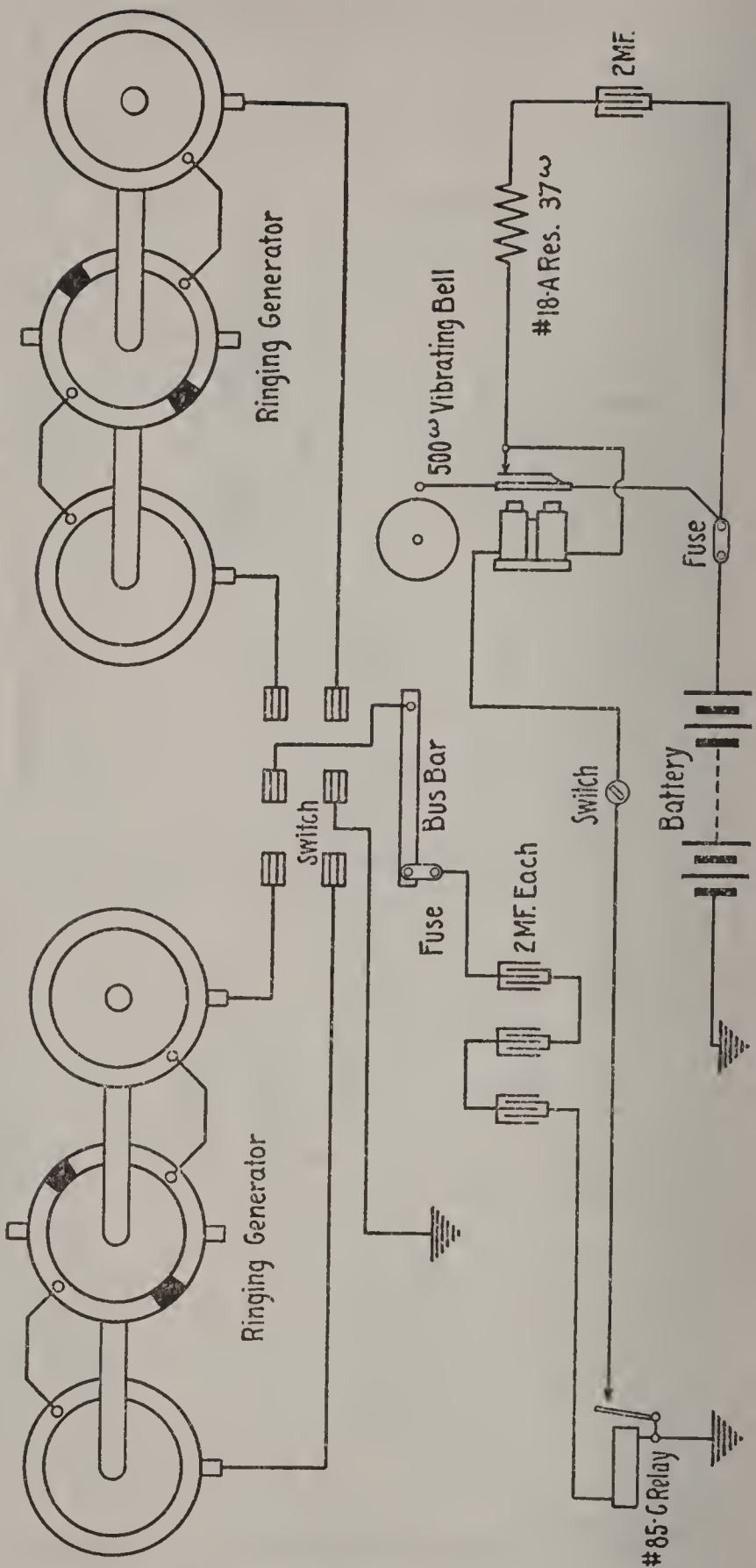

Fig. 31. Ringing Generator. Low Voltage Alarm.
(See page 122)

VENTILATING PLANTS

DEFINITIONS

Air Pump

A device used for compressing air for the operation of the automatic valves.

Automatic Valves

Valves operated by compressed air and controlled by thermostats and humidostats.

Diaphragm

That portion of the automatic valve operated by compressed air.

Duct—See Ventilating Duct

Fan

A mechanical means for circulating air through the ventilating ducts.

Heating Coils

Steam pipes mounted in the intake ducts.

Humidifier

A device for introducing moisture into the air.

Humidostat

A device operated by the amount of moisture in the air.

Register

An adjustable opening in the duct.

Screen

A cheese-cloth covered frame used to filter the air.

Thermostat

A device operated by changes in temperature.

Ventilating Duct

A sheet metal casing used to convey air.

DESCRIPTION

Ventilating plants are installed in central office buildings for the purpose of supplying fresh air, and removing the foul air, thereby avoiding, to a great extent, the necessity for opening windows.

Fresh air is drawn from suitable points outside the building and after being screened is forced, by means of large fans operated by an electric motor, through ducts, which terminate in registers near the ceiling of the operating rooms, the foul air being expelled through similar ducts which terminate in registers at or near the floor.

During the winter months, it is not desirable to deliver the air into the operating rooms at the outside temperature, and it is therefore suitably heated before it enters the ducts. This is accomplished by the use of heating coils placed near the mouth of intake and is automatically controlled by means of thermostats after the steam has been turned on at the required number of heating coils.

During the winter months the air should be 70° F. when delivered to the operating rooms.

Regulation of Temperature

A thermostat located in the intake duct is so arranged that it opens and closes a by-pass, thereby regulating the supply of cold air when the room temperature varies 2°F. above or

below normal. Another thermostat, located at the mouth of the intake, controls additional steam coils and is set to operate in extreme cold weather. Thermostats are also located in the operating and other rooms in connection with steam radiators and should, in general, be adjusted to open the valves at 68° F. and to close them at 70° F., but may be regulated according to the variation in temperature in different portions of the room.

A pump is used to compress the air for operating the automatic valves in the ventilating room and at steam radiators in operating and other rooms. When the pump is in operation, the diaphragm in the valve remains operated until the temperature of the room falls below the required degree of heat. The operation of the thermostat releases the air pressure and a spring forces the diaphragm in the opposite direction, thus opening the valve and permitting steam to enter the heating coils. When the temperature rises to normal the thermostat operates and the compressed air forces the diaphragm back and cuts off the steam from the heating coils.

Regulation of Humidity

A humidostat for regulating the humidity in the air is located in the intake duct in the ventilating room. This humidostat controls a valve which automatically opens and closes as the humidity varies from a pre-determined point and should be regulated according to weather conditions, or so that the humidity of the air in the operating room will be maintained at approximately 70%.

OPERATION

Whenever the ventilating plant is started or stopped the following operations are necessary in the order indicated:

To Start

1. Open shutters in intake.
2. Start motor.
3. Turn steam on heating coils.
4. Turn steam on humidifier.

To Stop

1. Stop motor.
2. Close shutters in intake.
3. Turn steam off humidifier.
4. Turn steam off heating coils.

NOTE: Operations 3 and 4 are unnecessary except when steam plant is in service.

In case of fire in the immediate vicinity of the central office the ventilating plant motor shall be stopped and intake shutters closed at once. This will prevent smoke being carried into the operating room through the ventilating system.

In certain cases, such as on very hot nights when it is not desirable to stop the ventilating plant as scheduled, arrangements may be made to have the Real Estate Department watchman do the necessary work.

CARE AND MAINTENANCE

Cleaning Motor

The motor and starting box shall be cleaned daily and weekly as described in the section on "Motors and Generators".

This work shall be done as near 8:00 A.M. as possible and two additional inspections of the motor shall be made during the day.

Maintenance

The Wire Chief will maintain the ventilating motor with associated apparatus and that portion of the wiring which is located in the room occupied by the motor, and will make minor adjustments to thermostats, humidostats and associated apparatus. He will also be responsible for the proper operation of the ventilating system. The Real Estate Department will maintain ducts, fans, screens, registers, heating coils, humidifiers, thermostats, humidostats, automatic valves, air pumps and associated apparatus.

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